2010/2011

Forest Genetics Council of BC

Tree Improvement Program

Project Report

Front Cover: Tree Seed Centre staff at work.

Back Cover: Seed Handling System.

http://www.for.gov.bc.ca/hti/treeseedcentre/index.htm

2010/2011

Forest Genetics Council of BC

Tree Improvement Program Project Report

Editors
Darrell Wood and Diane Douglas

Acknowledgements

Now in its fourteenth year, the Forest Genetics Conservation and Management Program, continues to meet provincial strategic objectives related to select seed production, genetic gains, genetic conservation, and reporting. Through the hard work and dedication of everyone involved this program is successful, and this year is no exception.

The broad program continues to focus on structuring for a changing climate and for the implications this has on forest management. One of the primary means by which we can respond is the matching of seedlots (genotypes) with future climates to ensure forests are well adapted to the climate in which they grow. This will result in better health, greater productivity and ultimately a more secure forest-based economy.

In response to this need, the Seed Transfer Technical Advisory Committee (STTAC) is identifying priorities for climate-based seed transfer research, structuring a program for delivery of this research, and providing oversight for new climate-based seed transfer standards. This work is directly aligned with priorities in the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) and receives the support of the Land Based Investment Strategy (LBIS).

As well, a Genetic Resource Decision Support Technical Advisory Committee was established to assist the Forest Genetics Council (FGC) in providing decision support to clients, particularly seed users. With government embracing "transformation and technology"; and in response to new technologies and methods of communication; this committee will provide a critical link in responding and developing the FGC approach to technology planning and innovation.

This Tree Improvement Program Project Report, in conjunction with the FGC Business Plan and FGC Annual Report, meets the reporting obligations of Council and the Forest Genetic Conservation and Management Pr gram. It provides a project-level overview of our efforts and highlights our successes.

Sincere thanks to the Project Leaders for submitting their contributions. A very special thanks to the reviewers, Michael Stoehr, Annette van Niejenhuis and Gary Giampa, and acknowledgments to all those who provided images for the report.

Again, thanks to all those who have worked on this program in the past year and over the past fourteen years; including Council members, review committees, species committees, various Technical Advisory Committees (TACs) and all the Project Leaders.

Darrell Wood
Manager, Business Operations
Tree Improvement Branch

The Forest Genetics Council Co-chairs invite you to review the programs and projects described in this report and return any questions or comments to:

Tree Improvement Coordinator
Ministry of Forests, Lands and Natural Resource Operations (MFLNRO)
Tree Improvement Branch
PO Box 9518 Stn. Prov. Govt.
Victoria, BC V8W 9C2

Further Tree Improvement information can be found at our web sites:

Forest Genetics Council	http://www.fgcouncil.bc.ca
MFLNRO, Tree Improvement Branch	http://www.for.gov.bc.ca/hti
	http://www.for.gov.bc.ca/hre/forgen/

FGC Forest Genetics Council of British Columbia

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Tree Improvement in British Columbia

The Forest Genetics Council of British Columbia (FGC) is a multi-stakeholder group reporting to the provincial Chief Forester and representing the forest industry, Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), the Canadian Forest Service, and universities. Council's mandate is to champion forest genetic resource management (GRM) in British Columbia, to oversee strategic and business planning for the provincial Land Based Investment Strategy (LBIS) Tree Improvement Program, and to advise the province's Chief Forester on forest genetic resource management policies. FGC Technical Advisory Committees (TACs) provide technical and policy information to Council and contribute to the development of FGC plans and associated budgets.

Council's vision is that BC's forest genetic resources are diverse, resilient, and managed to provide multiple values for the benefit of present and future generations. This vision is supported by six objectives that are set out in Council's Strategic Plan for the period 2009 to 2014 and reported upon annually. http://www.fgcouncil.bc.ca/Term%20of%20Reference%20-%20Oct10.pdf.

Annual business planning processes are designed to support achievement of the objectives, and the FGC Business Plan defines the annual set of activities and budgets needed to achieve objectives and realize the overall vision.

Forest genetic resource management is a co-operative effort in BC. In broad terms, the MFLNRO leads tree breeding activities and private companies contribute seed orchards. Orchard seed production is a collaborative effort between MFLNRO and the private sector. The MFLNRO, universities and consultants carry out research supporting operational GRM programs. Various co-operative advisory committees reporting to the FGC facilitate collaboration on a variety of support issues, including genetic conservation, climate-based seed transfer, orchard pest management, extension, and records management and decision support.

LBIS – FGC Tree Improvement Subprograms

The Land Based Investment Strategy Tree Improvement Program (LBIS-TIP) is structured to address the provincial strategy for forest genetic resource management developed by the Forest Genetics Council. There are eight subprograms:

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

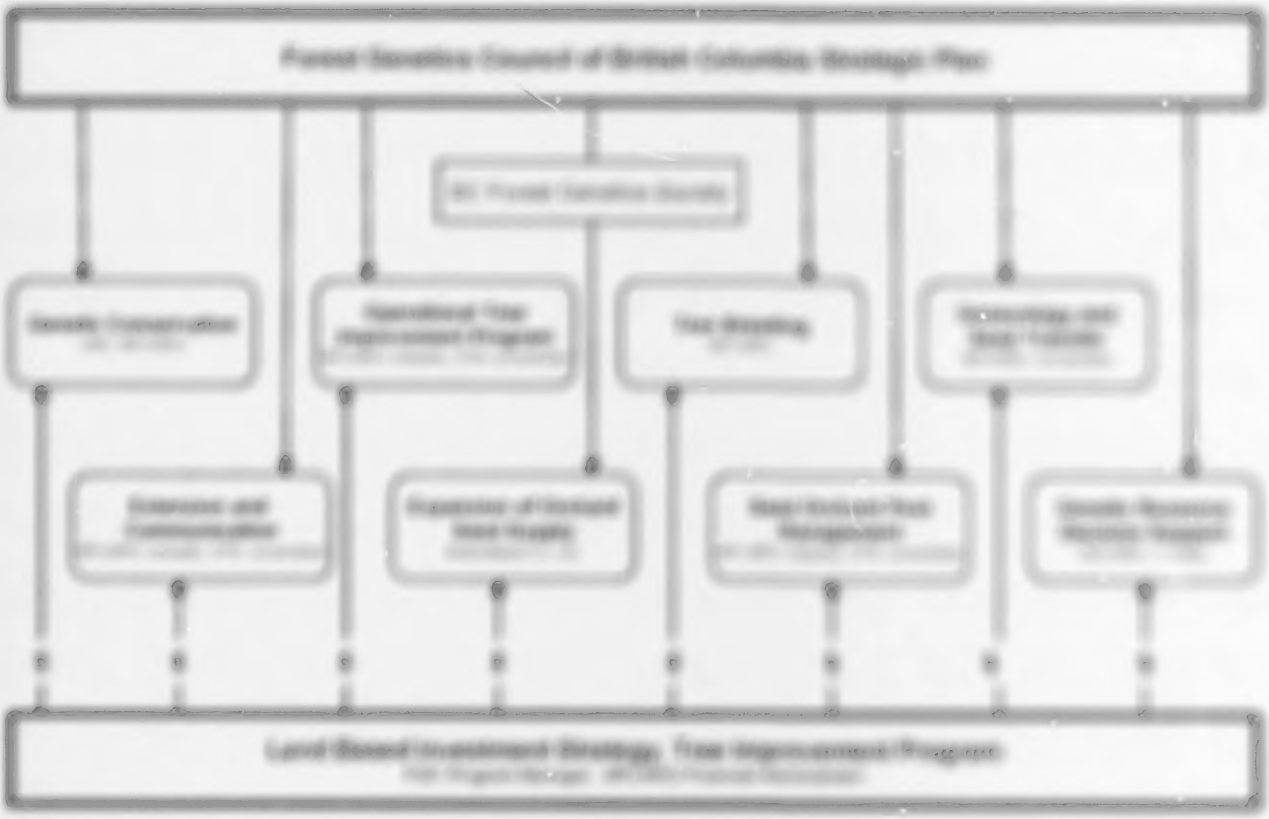

Forest Genetics Council of British Columbia Strategic Plan
BC Forest Genetics Society
Genetic Conservation
Operational Tree Improvement Program
Tree Breeding
Extension and Communication
Extension of Improved Seed Supply
Seed Orchard Pest Management
Land Based Investment Strategy Tree Improvement Program

Figure 1 – Relationship between FGC Strategic Plan, LBIS-TIP and participants in various forest genetic resource management roles.

1.0 Expansion of Orchard Seed Supply Subgroup 100 Outer Coast Co. Ltd.

[illegible]

[illegible]

[illegible] Company Ltd., a wholly owned by the Provincial Council of BC (PCC), and operated under the leadership of a Board of Directors. [illegible] member from the PCC, is a certified seed orange seed orchard located at about PCC. Operations [illegible] to provide an genetic [illegible] seed to [illegible].

[illegible] Seed Orchard is a [illegible] through a [illegible] and Forest Seed Development Strategy (SSDS) [illegible]. As such [illegible] and seed orchard operations. SSDS [illegible] as [illegible]. We expect that all [illegible] will be [illegible] from seed [illegible] the [illegible] Seed Orchard [illegible] operations are guided by an annual business planning process that is reviewed and approved by the Seed Orchard Board of Directors and the PCC. All [illegible] orchard investments are thoroughly [illegible] and the private sector.

[illegible] also provide program management services to the PCC, including [illegible] and [illegible] reports, preparation support for [illegible] development, recruiting [illegible] services, [illegible] of [illegible] and planning issues, staff [illegible] and accounting functions.

[illegible]

Starting the [illegible] year ending [illegible], [illegible] orchard [illegible] [illegible] of the [illegible] crop is [illegible] [illegible] from [illegible]. Total [illegible] [illegible] [illegible] produced a total of [illegible] [illegible] of cones, yielding [illegible] kg of seed. [illegible] [illegible] of this crop was [illegible] kg, with the remainder of the seed going to the [illegible] [illegible] operating the orchard. [illegible] [illegible] crop [illegible] [illegible] [illegible]

[redacted]

[redacted]

[redacted]

[

Maintenance of ClimateBC/WNA (Tongli Wang)

The continual updating and improvement of climate models continues to keep Tongli Wang busy. Models have been updated with new version of GCMs from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment. A manuscript entitled "ClimateWNA – High-Resolution Spatial Climate Data for Western North America" has been submitted to the *Journal of Applied Meteorology and Climatology*.

Climatic response of ancestral lands and western red-cedar populations evaluated in controlled climate chambers (Yue Liang)

This experiment measures the response of twenty well-chosen seed lots of each of western larch and western redcedar to five temperature regimes and two drought levels. From these data, we derive the response curves which help us predict response to future climates. Previous projects have included lodgepole pine, interior spruce, and whitebark pine. ShrubGA developed by Yue Shuzhi to simulate a range of climatic conditions using growth chambers continues to improve, and to produce interesting results. The first replication was sown in February 2010 and the second in September 2010. Treatments were applied throughout the year and height measurements were made at regular intervals. Fluorescence measurements were carried out to evaluate drought stress. We are in the process of making the final measurements on the plants of the second replication. The experiment was successful, with clear treatment and population differences. Significant mortality in the second year was a desired outcome and reflects the impact of extreme temperature, drought and competition. Cold hardiness testing will take place in April and will complete the adaptation picture. These highly phenotypically plastic species have shown very strong environmental response to these temperature regimes, but have also shown genetic variation in these responses. As previous work has been with largely determinate, low plastic species, these results will be of note both for these species in particular and for our understanding of conifer response to climate in general.

Conservation genetics of non-commercial broadleaf species (Jordan Bemmels and Lisa Lyon)

The CPCG's research on the population genetics and genecology of Pacific dogwood has wrapped up with the completion of a scientific manuscript based on the MSc research of Katelyn Katz and the BSc (Hons) research of Jordan Bemmels (funded by the PGC, GCTRC and NSERC). The Garry oak genecology trial at UBC was assessed for stem form in 2010 by undergraduate research assistant Lisa Lyon. We anticipate distributing results in the form of a scientific manuscript in 2011 based largely on Colin Hudson's MSc research with the addition of these new measurements.

Genetic structure and conservation genetics of interior spruce (Amanda De La Torre)

Interior spruce comprises *Picea glauca* (white spruce), *Picea engelmannii* (Engelmann spruce), and their hybrids. We genotyped 750 progeny in the interior spruce breeding program from the East Kootenays, West Kootenays, Mt. Robson and Quesnel Lake breeding populations for 384 single nucleotide polymorphisms, and genotyped another 400 parent trees in the breeding program and putative 'pure' white spruce (Fort Nelson) and Engelmann spruce (ESSF populations) for 10 microsatellite loci. Phenotype data were provided for the progeny by Barry Jaquish.

The majority of genetic resources show an elevational cline in allozymes corresponding to climatic gradients in temperature and precipitation. The high number of advanced-generation hybrids indicates that introgression is extensive and that the zone is possibly of ancient origin. Preliminary analyses suggest that introgression is asymmetric towards Engelmann spruce, with apparently pure Engelmann spruce over 1400 m in all four breeding zones, and many individuals that are 50-100% Engelmann (e.g., backcrosses of hybrid individuals to Engelmann spruce), but relatively few trees that are more than 50% white spruce (e.g. backcrosses to white spruce) and almost no 'white spruce' throughout these four zones. The asymmetry towards Engelmann spruce may be a result of differences in phenology or other incompatibilities. If a bias towards hybrid reproduction exists, it may present a challenge to tree breeders and seed orchard managers as Engelmann spruce is slower growing than white spruce and with climate change will become less adapted to many reforestation environments.

Meta-analysis of adaptation to climate across western North America in species (Jordan Bemmels)

Given the wealth of past genecological projects conducted in BC and elsewhere in western North America, we have initiated a new meta-analysis of provenance trial results for all species to quantify and compare the climatic

clines of these species for quantitative traits including growth, timing of bud break, timing of bud set, and cold hardiness. For species with published or available population source location details and mean quantitative trait values, Research Assistant/Technician Joshua Hommuk has converted geographic location data to climatic source data using Climate WNA, and estimated clines for standardized traits using regression analyses. Our hope is that this will provide us with information on the extent to which genotype-climate relationships vary among species, and whether generalizations can be drawn about adaptive generalists versus specialists (partially funded through NSERC Discovery Grant).

2.2 Research Branch Conservation Activities

Jodie Krakowski

During the past year, the MFLNRO conducted a range of activities in support of genetic conservation, ranging from a field-oriented large study to delivering extension.

Field verification of in situ conservation of BC tree species

As a follow-up to the pilot study of 2009-2010, a comprehensive field survey was conducted to ground truth estimates provided in Chourmouzis et al. (2009)[1] to determine the accuracy of the modelling method used to predict population abundance in different parts of the province. A publication is planned summarizing the key findings.

Methods: To most efficiently use areas with conservation concerns, areas of the province with the highest concentration of species that were predicted to be potentially underprotected were systematically surveyed using a stratified sampling design with fixed-area transects. A total of 149 park-biogeoclimatic zone combinations were sampled encompassing the CDF, dry CWH variants, and the BG, PP, and IDF zones, for a total of 29 parks in the interior and 89 on the coast. Twenty-two species were sampled on the coast and 22 in the interior, focusing primarily on non-commercial species.

Results: Findings determined that many "minor" or non-commercial species were relatively abundant and models tended to under-predict their occurrence. Species with ecologically restricted or scattered distributions tended to be dramatically over-predicted. However, depending on the habitat niche and land use patterns of each species, being less common than predicted did not necessarily correspond with conservation risk – often species that are restricted to narrow ecological niches are abundant within a small area, and species that naturally have a sparse distribution may never be abundant and this distribution pattern does not translate into being at risk.

Predictions of abundance for many minor species especially for a given park, were not borne out by observations. On the coast, 0 to 43% of coastal species were predicted to be present when they were actually present, and in the interior the accuracy of prediction for presence was 0 to 55%. Predictions of species absence were more reliable, but highly variable among species. There were also discrepancies on which parks were predicted to have large population sizes. On the coast, the species that were most overpredicted in terms of the number of parks with adequate protection levels were Garry oak, grand fir, and Sitka spruce, and the most underpredicted species were arbutus and crabapple. In the interior, the most overpredicted species were ponderosa pine, paper birch, and aspen, while the most underpredicted was pin cherry. There were very few cases where actual abundance of any species was within 90 to 200% of the predicted abundance for a given park.

Commercial species, although not included in the analysis, tended to be far more abundant than predicted, primarily for generalist species such as lodgepole pine, Douglas-fir, and western hemlock; species with more restricted habitat requirements were often absent or less common than predicted.

Follow-up: The predictive accuracy based solely on ecological inventory plots, in combination with underlying model assumptions, is too inaccurate to base conservation decisions upon. Genetic conservation objectives may be better met by obtaining baseline genetic data on population differentiation to assess whether population variability is adequately conserved based on genotypic traits, potentially in combination with adaptive differentiation.

Ex situ conservation collections

2010 was an excellent year for *ex situ* conservation, with both whitebark and limber pine yielding good crops in areas not previously represented in provincial inventory. In collaboration with graduate students, non-profits,

1 Chourmouzis, C., A. H. Yanchuk, A. Diamandis, P. Smets, and S. N. Aitken. 2009. Forest tree genetic conservation status report 1: In-situ conservation status of all indigenous British Columbia species. Centre for Forest Conservation Genetics, Forest Genetics Council of B.C., and B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C., Tech. Rep. 053. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr053.htm

consulting firms, ski hill operators, and First Nations, access was secured for a very broad range of difficult to access sites. Seed for conservation as well as other activities for these partners who were able to collect seed for their own needs including producing seedlings for restoration was collected.

Highlights included collections throughout the Yalakom Valley north of Lillooet, several whitebark pine habitats in the Fraser Canyon, remote areas in the East Kootenays, and ski hills including Kicking Horse at Golden and a massive collection at Mount Baldy near Rock Creek.

Yellow Point Propagation coordinated and/or conducted seed collections for 2010-11. Other species that were collected were Rocky Mountain juniper, Pacific flowering dogwood, and cascara. In 2010-11, GCTAC priorities will continue to guide seed collections with the multi-year objective of broad representation of populations of most minor species securely conserved in the Tree Seed Centre, with seed surplus to conservation criteria potentially available for research projects and restoration.

Whitebark pine support activities

The primary activities related to whitebark pine genetic conservation in 2010-11 were focused on *ex situ* seed collection (see above). GCTAC continues to play an important role as a resource and liaison for information, finding partners, tracking seed availability, and supporting extension and volunteer work in whitebark pine. Priorities for GCTAC support will be guided by the Whitebark Pine Genetic Conservation Strategy, which is available at:

http://www.for.gov.bc.ca/GCTAC-WhitebarkPine-GeneConsStrat-BC-2009.pdf

While not formally affiliated with GCTAC, the Whitebark Pine Ecosystem Foundation (WPEF) of Canada was formally established as a nonprofit society in 2010 to support restoration, education and research projects. WPEF-Canada will be hosting a field workshop in Lillooet in July 2011 showcasing recent studies and conservation efforts in a spectacular setting offset by the devastation of recent large wildfires. For more information see: www.whitebarkpine.ca.

Extension

A poster series was published highlighting the role and importance of genetic conservation in British Columbia forests. Five posters make up the series, providing information on: 1)the MFLNRO genetic conservation program, 2) genetic conservation as an element of forest management, and genetic resource management issues associated with, 3) western white pine, 4) western redcedar, and 5) western larch.

The posters can be downloaded from the Production Resources website
http://www.for.gov.bc.ca/hfd/pubs/Docs/P/P085.htm

and hard copies can be ordered from Crown Printing
http://www.for.gov.bc.ca/hfd/pubs/orderinfo.htm

toll free 1-800-663-6105, Victoria (250)387-6409, fax (250)387-1120.

3.0 Tree Breeding

3.1 Coastal Douglas-fir Program

Michael Stoehr, Keith Bird, Lisa Hayton

This year the program focused on final establishment and ID tagging of our Series 4 (EP 708.24) and additional Series 3 (EP 708.23.1) progeny trials for SPU1. Excellent survival on all newly planted sites has been noted to date. Extensive ID checks and tagging were performed on earlier established trials, Series 2 (EP 708.22), prior to measurements and data collection. After data analysis, selections and collections from Series 2 (EP 708.22) have now been grafted for future distribution to SPU 1 orchards. Breeding values (based on age 9 years) of the forward selections ranged from 16 to 23 (% volume gain at rotation of 60 years).

Selections continued to be distributed to client seed orchards in fall and spring lift orders for SPU 1 and SPU 19 (SM zone of Fdc). Further collection and grafting of Series 1 continued and will be distributed when ready along with clone banking of all high breeding value (BV) material available. Again good survival has been noted. Fall 2011 measurements and data collection has been set for Series 3 (EP 708.23).

Maintenance, measurements and data collection was completed on all sites in our EP 1200 (SM zone of Fdc) and now has analysis in progress.

Thirty-five year measurements were completed on three EP 708 sites (#23 Adam, #28 Fleet, #33 Lost) to check against earlier measurements to validate the selection criteria and to evaluate possible competition effects on height superiority of previous selections.

Rooted cuttings trials were initiated to study the efficacy of producing large quantities of improved Fdc material for future seed orchard distribution. The goal is the possible elimination of the grafting phase to allow for quicker "bulking up" of requested material and avoidance of potential graft incompatibility. Three successive monthly collections were set using two hormone and two zone stratifications of the selected donor trees. Analysis is continuing.

Seedlings from previous full-sib crosses are being grown this year at Cowichan Lake Research Station (CLRS) to be used on future studies including possible Swiss Needle Cast and bud worm pest issues.

Our realized gain study was measured at age 12 and the estimated genetic height gains appear to be realized at this stage (Figure 2) with top-cross (tc) material performing best on four of the five test sites and mid-gain (mg) seedlings being intermediate to top-cross and wildstand controls.

However, in volume per tree, the additional gain in diameter growth caused larger than expected gains (Figure 3) in both mid-gain and top-cross seedlings. No spacing by genetic entry interactions were observed, indicating that spacing does not cause any rank changes in performance.

List of Publications

El-Kassaby, Y.A., S. Mansfield, F. Isik, and M. Stoehr. 2011. *In situ* wood quality assessment in Douglas-fir. Tree Genet. Genomes 7:553-561.

Stoehr, M., K. Bird, G. Nigh, J. Woods, and A. Yanchuk. 2010. Realized genetic gains in coastal Douglas-fir in British Columbia: Implications for growth and yield projections. SilvaeGenetica 59(5): 223-233.

Stoehr, M., J. Woods, K. Bird and L. Hayton. 2011. Verifying genetic gain estimates in coastal Douglas-fir in British Columbia. Min. of Forests and Range, For. Sci. Prg. Ext. Note 104.

Stoehr, M., J. Woods, and A. Yanchuk. 2011. Selection Approaches in High-Elevation Coastal Douglas-fir in The Presence of GxE Interactions. Silvae Genetica 60(2): 79-84.

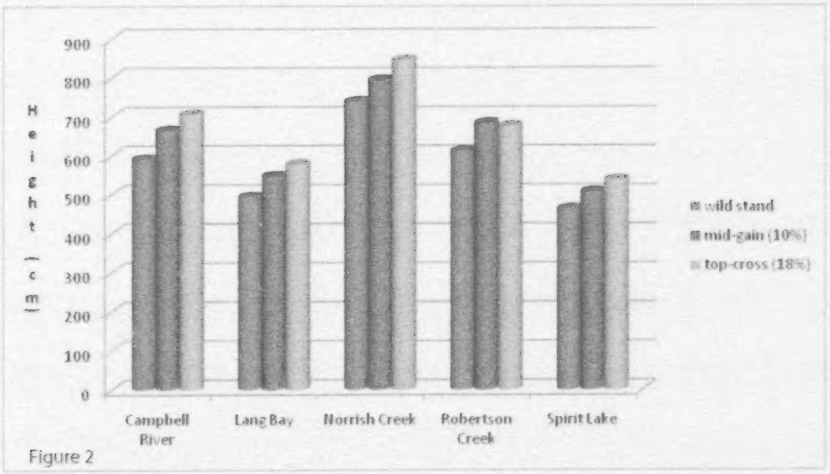


Figure 2. Observed average 12-year heights (cm) of trees of three genetic classes in coastal Douglas-fir at five test locations across four spacings.

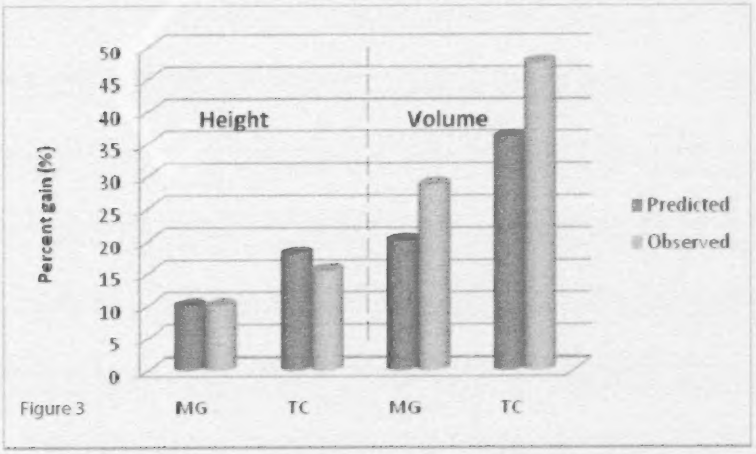


Figure 3 . Observed vs. expected gains in heights and individual tree volume for mid-gain and top-cross old coastal Douglas-fir trees across five test sites and four spacings at age 12 years.

3.2 Western Hemlock Forest Genetics Program

Charlie Cartwright

An internal review of this program was undertaken in the fall of 2010 and new goals were developed. Since planting of hemlock is no longer the usual practice on the BC Coast, the focus of the program will be to remain on maintenance of installations already established to secure investment in them. An exception to this was that the review committee recommended measurement of one advanced generation trial in order to meet obligations to the Hemlock Tree Improvement Co-operative (HEMTIC). Ties to HEMTIC may prove a benefit in the long term as the co-op advances to a third breeding generation buoyed by annual plantings of roughly 8 million seedlings per annum in the United States. Since material from BC is included in the forward development of that program, as well as parent trees from Washington State shown to be well adapted to our climate, suitable third generation seed may eventually be available to us from American members of the co-operative.

For the high elevation program (SPU 24) trials a similar approach was supported by the program review. High elevations tests will be maintained, but other activities will not be undertaken. Consequences of delaying measurements for the installations at higher elevations are less substantial due to the slower growth rates they exhibit. Whether planting numbers increase or not over the next few years, a synopsis of program developments since the last all encompassing document of 1997 will be issued.

3.3 True Fir Forest Genetics Program

Charlie Cartwright

Interest in subalpine fir is increasing in the province's Interior due to decimation of lodgepole pine stocks and the need to supply mills with green logs. More emphasis on harvesting of higher elevation stands has not translated into a much greater use of subalpine fir seed, but planning should anticipate somewhat increased seed requests. Scheduled maintenance of 8 recently established provenance trials and measurements of 3 older farm field test sites was completed. As well 2 new field sites were added, one near Williams Lake and another in the Rocky Mountain Trench. Replacement stock was sown for sites with poorer survival resulting from unavoidably late planting dates.

For the Pacific silver fir program 7 sites were maintained and 7 were measured as planned. Analysis of data from 4 ten year old low elevation provenance trials will allow for the identification of superior provenances and possible sourcing of B+ seedlots. Although low elevation transfer guidelines could now be revised, it is wiser to wait for data from the later series of tests which were planted more broadly and particularly at higher elevations and in the Coast/Interior transition.

With noble fir, the old provenances trials have been visited where possible, access notes updated, and signage and tags checked. Scions from range-wide provenances have been collected from the trials to serve genetic conservation aims and represent good form, best adapted provenances.

For grand fir similar activities have taken place. Four older trials have been maintained (all but one with water table problems) and feature impressive growth. (Plate 2) Signs and tags were checked and access notes updated.

Plate 2. Thirty year old grand fir provenance trial.

3.4 Western Redcedar Breeding Program

John Russell and Craig Ferguson

The western redcedar breeding program is moving towards developing durable populations for resistance to current, and future known and unknown, biotic threats as well as maintaining adaptability and growth. Current known biotic threats include ungulates, heartwood fungi and cedar leaf blight. Understanding resistance mechanisms for these organisms has been ongoing and a key component is secondary extractives, both in the foliage and heartwood.

We are also beginning to explore cross resistance and genetic correlations among the different biotic threats, and with growth. Figure 4 illustrates that monoterpenes in the foliage exhibit a slight positive correlation with heartwood tropolones. The blue box in Figure 4 depicts selections that can be made for both deer resistant clones (positive values for foliage monoterpenes) and heartwood rot resistant clones (positive values for tropolones).

A deer resistance population has been developed by selecting individuals with high needle monoterpene concentrations. A resistant seedlot and vegetative lot (veglot) are currently being developed for operational deployment trials (Plate 3).

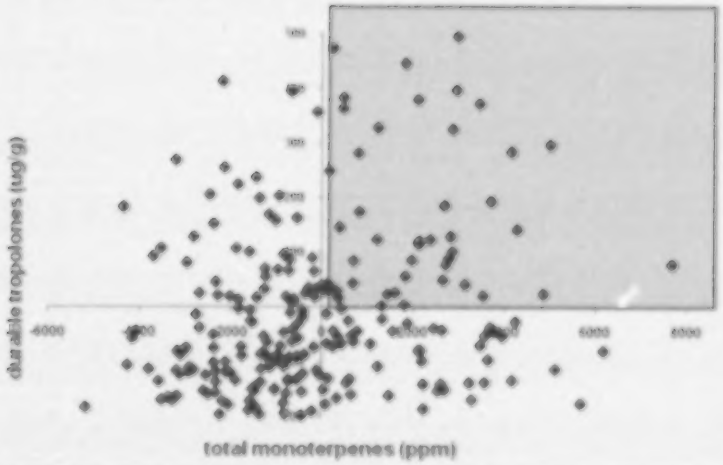


Figure 4. Relationship between foliage monoterpenes and heartwood tropolones clonal values.

Plate 3a. Breeding for deer resistance seed; Plate 3b. Donor stock for propagating deer resistant clones.

3.5 Yellow Cypress Breeding Program

John Russell and Craig Ferguson

This program is currently focussing on maintenance and measurements of the clonal full-sib field trials. A select clonal population with a genetic gain of 20% volume has been established with serial propagated donors in greenhouses at CLRS (Plate 4). This elite veglot has the potential to be 35% greater in early height as compared to wildstand seedlots across a wide range of ecosystems within the yellow cypress maritime SPU.

Plate 4. Yellow cypress clonal donor stock at Cowichan Lake Research Station.

3.6 Coastal Broadleaf Species Genetics Program

Chang-Yi Xie, Doug Ashley, Lisa Hayton and Keith Bird

Commercial planting of red alder is expanding, seed orchard establishment is in the planning stage, and a breeding program is under consideration. To assist seed orchard management and tree breeding, a red alder reproductive biology study has been initiated to provide information on male and female flower production, and timing of pollen shed and female receptivity for each clone in the clone bank.

Pollen collection, processing, storage, and viability testing methodologies will be developed. Polycrossing of high breeding value clones will be completed in 2012 and second-generation progeny tests will be established in 2013/2014.

A manuscript reporting the 3-year test results of black cottonwood at Terrace has been accepted for publication by the Canadian Journal of Forest Research. The 5-year assessments have been accomplished at Terrace and Red Rock and 3-year assessment has been completed at the Harrison site. Data will be analyzed and the results will be used for clonal selection this fall. Brushing and re-tagging at Terrace and tilling, spraying and tag removing at the Harrison site were done. A new beaver fence at the Harrison site was also established.

All 4 big-leaf maple test sites (Skutz Falls, Sayward, Powell River and Carey Island) were well maintained and permanent tags were installed. Three year assessments at all 4 sites were accomplished this spring. Data will be analyzed this fall.

3.7 Interior Douglas-fir Tree Breeding Program

Barry Jaquish, Val Ashley, Gisela Phillips and Bonnie Hooge

The BC Interior Douglas-fir tree breeding program began in 1982 and focuses largely on productive forest lands in the central and southern Interior. Within this wide-ranging land base, six seed planning units (SPUs) have been delineated for tree improvement. The first cycle of breeding in each SPU is based on: 1) phenotypic selection in wild stands, 2) establishment of grafted breeding orchards and clone banks, 3) progeny testing using open-pollinated (OP) seed from wild stand trees, 4) delayed-foliage seed orchards established with backward selected parents based on early progeny test results, and 5) controlled mating to produce pedigree material for second-generation selection. Tree height, diameter and volume are the major traits for improvement, while wood relative density is an important secondary trait. The recent discovery of resistance to *Armillaria* root disease in Interior Douglas-fir suggests that resistance to *Armillaria* could become an important trait of interest. Plans are currently in place to expand the screening of Nelson SPU parents for resistance to *Armillaria*. The first-generation progeny testing program includes 1,466 OP families from the six SPUs. Seed orchards were established in the north Okanagan in the early 1990's and are coming into production. In 2010, selected parent trees from southern zones were identified to establish new 1.5 generation seed orchards for the Thompson Okanagan high and low elevation SPUs. The Thompson Okanagan region was avoided in the program's early stages because of low productivity; however, recent increases in planting numbers combined with severe seed shortages for the area necessitate the establishment of orchards for these lands. Nearly 1.3 million class 'A' Interior Douglas-fir seedlings were planted in BC in 2010, which represents about 11 percent of the year's total planting of Interior Douglas-fir.

The second-generation crossing program focuses on the Nelson SPU and includes selected parents from the West Kootenay, Shuswap Adams and Slocan regions. Since inter-varietal (coastal x interior Douglas-fir) hybrids have proven to be hardy and fast growing in the Nelson low elevation zone (Plate 9 a and b), the Nelson second-generation breeding population has been augmented with 10 high breeding value parents from the BC coastal breeding program and 10 Forward selections from superior Submaritime provenances in the Trinity Valley range-wide Interior Douglas-fir provenance test (Plate 6).

Ministry restructuring and constant bud x significantly negative effect on 2010 crossing activities. In total, 76 controlled crosses were completed on six Douglas-fir SPUs and 37 pollen lots were collected, processed and stored for future breeding. Controlled crossing for the Nelson SPU remains about 80 percent complete. In fall 2010, 10 progeny tests in three SPUs were maintained and measured, and the 35 year-old Trinity Valley range-wide provenance test was measured. As Trinity Valley seed sources from the Coast-Interior transition zone continue to outperform local Interior seed sources.

Publications

Xiao-Xin Wei, J. Beardmore, D. P. Khasa, J. Vargas-Hernández, J. López-Upton, B. Jaquish, and J. Bousquet. 2011. Range-wide chloroplast and mitochondrial DNA imprints reveal multiple lineages and complex biogeographic history for Douglas-fir. Tree Genetics and Genomes. Accepted.

Plate 5. [illegible] year-old Douglas-fir [illegible]

Plate 6. Young grafts of high breeding value coastal Douglas-fir parents in Kalamalka Trees will be used in controlled crossing with interior parents from the Nelson seed planning unit

3.8 Interior Spruce Tree Breeding Program

[illegible]

Interior spruce is the oldest tree improvement program in the BC Ministry. Parent tree selection and genetic testing began in the mid-1950s and expanded rapidly through the 1970s. The first phase of the program focused on three ecologically and geographically unique regions: Prince George, Bulkley Valley and Fort St. John. Phase two began in the mid-1970s and centred on the remaining geographic regions where interior spruce was commercially and ecologically important. The program has progressed to the point where much of the current planting stock (96 million seedlings per year) comes from improved tree generations and orchards. Full (1st generation) program data are in place for Prince George, Fort St. John and Headwaters (FTA). In the Prince George Seed Use region, 69 1st generation seedling orchards have been established and [illegible]

[illegible] 1st generation selection is now [illegible] the Nelson Seed Orchard (FTA). Unfortunately, no comparable [illegible] has been completed in the Prince George Seed Use region.

[illegible]

Figure 1. [illegible]

2.8 Western Larch Tree Breeding Program

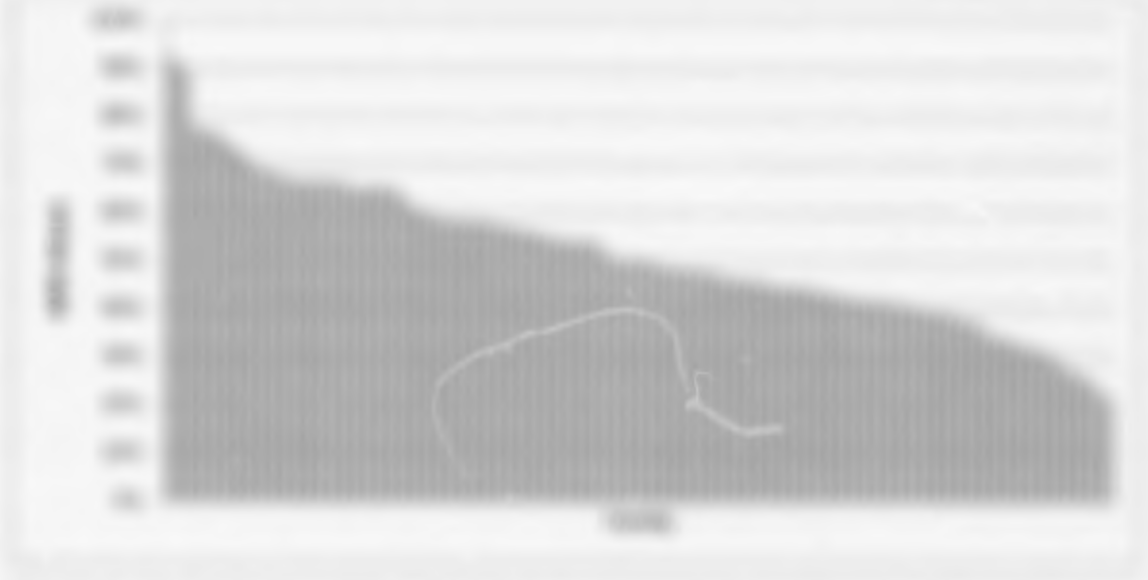
[redacted]

[redacted]

2.10 Lodgepole Pine, Western White Pine and Interior Figure Work

[redacted]

[redacted]



Western White Pine

The supply of future rust resistant western white pine seed in the interior of BC is produced at the Bailey Seed Orchard (orchard 337) in Vernon. The seed orchard is composed of a combination of parent trees imported from Western Idaho, and local seedlings from BC. The parent trees from Idaho were selected from a 17 year old, full-sib family screening trial growing at the Priest River Experimental Station. The full-sib families were created by inter-crossing rated and selected first generation parents. Seed from BC parent trees was screened for rust resistance at Cowichan Lake Research Station. Surviving trees were selected for having good resistance reactions to white pine blister rust. Scions were eventually collected from selected trees, grafted and planted in the seed orchard. The genetic material now located in the Bailey Seed Orchard will form the breeding population for future breeding activities.

The western white pine breeding program has undergone a program review and the recommendation was to continue to focus on producing rust resistant material for seed orchards. The future of the breeding program in the interior will focus on conducting control crossing amongst various sources and establishing a series of progeny tests which will be used as a source of material for future orchards. These tests will allow us to select trees which are superior for blister rust resistance and growth while maintaining other traits and disease hazards. We are collecting scions from the Bailey Seed Orchard for a long-term clone bank and breeding arboretum at the Kalamalka Forestry Centre in Vernon which will aid in breeding activities and we are planning to begin breeding activities in 2013-2015. We are also continuing to explore the concept of emergent resistance (age related resistance) and are growing the final age class for the Age Related Resistance Trial (ARRT) and Bitler plants for inoculations in 2015.

Interior Paper Birch

The interior paper birch program consists of three test series which assess several provenances and families across a wide range of test sites. EP 1068.11 tests 18 provenances collected across the range of interior paper birch on 5 test sites from Kispiox to Creston. EP 1068.12 is located at Skimikin Nursery and contains open pollinated families collected from 33 stands in the Kootenay Region. EP 1068.13 is an elaborate genecology study planted on three test sites (Prince George, Skimikin and northern Idaho) and contains several latitudinal, longitudinal and elevational transects.

EP 1068.12 located at Skimikin Nursery was rotted and removed after collecting scion material from forward selections for the paper birch seed orchards located at the Kalamalka Seed Orchard and Skimikin Seed Orchard. Four sites from EP 1068.11 and two sites from EP 1068.13 were measured for height and diameter growth and were brushed to remove competing vegetation. The data will be used to generate seed transfer guidelines for a future climate based seed transfer system.

3.11 Assisted Migration Adaptation Trial (AMAT)

Greg O'Neill, Michael Carlson, Vicky Berger, Nick Ukrainetz

The AMAT is a long-term field trial of orchard seedlots that will help refine seed source selection to ensure that plantations are adapted, productive and healthy well into the future. Despite several significant administrative and financial hurdles arising from the recent recession, the Assisted Migration Adaptation Trial (AMAT) is still on track. During fiscal 2010/11, the second series of 12 sites were established; seedlings for the third series were sown, grown and lifted; and sites for the third series were identified and prepared. Formal agreements with several American collaborators as well as environmental impact assessments with Yukon government and USDA Forest Service were completed, paving the way for establishment of the third series of test sites which will range from Sacramento, California to Whitehorse, Yukon. Seedling import permits were arranged by Michael Carlson, who also coordinated 11th hour negotiations with the USA consulate to allow our planting contractors to work in the USA.

Considerable effort was devoted toward extension activities in fiscal 2010/11. The project was presented or discussed at the following meetings, tours or publications:

- Southern Interior Silviculture Committee (SISCO), Nanaimo, BC (April 2010)
- Canadian Forest Service – Laval, QC (June 2010)
- Jaime M. Poor Research Symposium, Chicago Botanical Gardens (June 2010)
- MLA Eric Foster, Vernon (July 2010)
- Chief Forester, MFLNRO, Vernon (July 2010)
- Northern Silviculture Committee (NSC), Vanderhoof (Aug 2010)
- ADM, Competitiveness and Innovation Division, MFLNRO, Victoria (Aug 2010)
- UBC Okanagan, Kelowna (Sept 2010)
- Science Illustrated (Sept/Oct 2010)
- Coastal Forest Genetics Extension Symposium field tour, Jordan River – (Dec 2010)
- Business Week (Dec 2010)
- BC FGC Interior Technical Advisory Committee – Vernon (Jan 2011)
- FoRecTInC – European Union climate change workshop – Flagstaff, Arizona (Feb 2011)
- FORREX, teleconference (Feb 2011)
- Canadian Forest Service – Victoria (March 2011)

The AMAT team is collaborating with researchers at UNBC, UBC and Oregon State University, providing seed or seedlings for 5 projects. The AMAT team thanks its many collaborators who have kindly provided advice, seed and test sites, and looks forward to developing further collaborations.

Plate 10. Map of AMAT test sites identified to-date (March 2010) and seed source locations. (Map credit – Matt LeBoy)

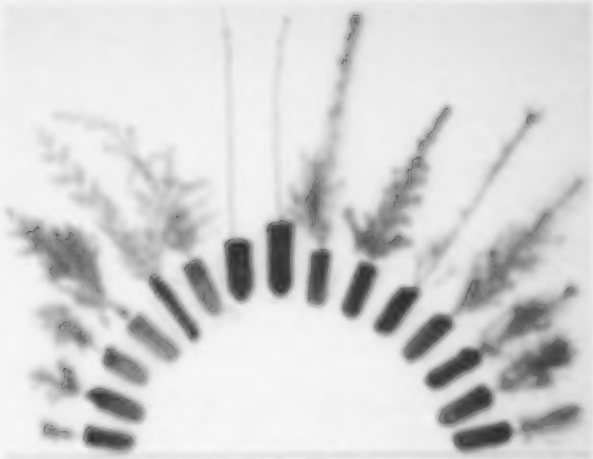


Plate 11. Species tested in AMAT. (Photo credit – Wood Stronq/Michael Carlson)

4.0 Seed Transfer Technical Advisory Committee

Lee Charleson

The Seed Transfer Technical Advisory Committee (STTAC) continues its work developing priorities in genecology research, vetting project proposals and providing budget recommendations to FGC for genecology and seed transfer research. Additionally, the STTAC raises genecology and seed transfer issues to CTAC and ITAC for their information and consultation.

The identification of priorities has changed from the previous year. As the bulk of genecology projects are conducted by ministry forest genetics research staff, STTAC agreed to have priorities and funding needs identified and documented directly by the ministry forest genetics research team with the work led by John Russell. In fall 2010, a rough draft was prepared of a three year genecology research plan which was submitted to STTAC in the fall. Qualifications for funding ministry work will be determined by ministry forest genetics research staff and manager in accordance with the research plan. One condition requested by STTAC is that a short lay summary be prepared and submitted annually for each project that will receive FGC funds in genecology.

The TAC retains an open call for proposals which will be a small, low budget call for other innovative ideas to be tried and tested beyond the ministry. The priorities for acceptable tree species and projects are based upon the 2009-2010 priorities table and the uniqueness and innovation of the proposed project.

Five projects were submitted to the call for proposals in winter 2010-2011. A review committee, smaller than last year, was convened to assess the proposals. Based upon the review committee's work, STTAC recommended to FGC that three proposals be fully funded, one proposal be partially funded and one proposal not meeting criteria in the call for proposals not be funded.

For a complete list of genecology projects in 2010-2011, see Table 1, the same information is posted on the STTAC webpage at http://www.fgcouncil.bc.ca/sttac-area.html. One final report, from the project lead by Phil LePage, was generated. To view the report, *Assessment of Off-Site Tree Plantations in the Northwest Interior of British Columbia -Project Summary*, see:

http://www.fgcouncil.bc.ca/Off-Site_Species_Assessment_Final_Report_Opt.pdf

Species	Project Leader	Project Title
At	Chris Hawkins	Genecology of Aspen in British Columbia
Ba	Charlie Cartwright	EP0804 - Provenance Studies of Pacific Silver Fir
Bl	Charlie Cartwright	EP0804 - Provenance Studies of Subalpine Fir
Bl and Ba	Sylvia L Mcintosh	Patterns in frost, heat, and drought response of Abies lasiocarpa and Abies amabilis populations from a range of climates
Cw	John Russell	Western redcedar interior climate change and seed transfer study
Cw and Lw	Sally Aitken	Climatic response of western redcedar and western larch seed source using controlled climate chambers
Ep	Nicholas Ukrainetz	Provenance test variation for paper birch in the interior of British Columbia for the development of transfer functions for a Climate Based Seed transfer system
Fdc	Marty Kranabetter	Coevolution of ectomycorrhizal fungal communities with local provenances of coastal Douglas-fir and the implications for assisted migration
Fdc	Michael Stoehr	Seed transfer study in the coastal Douglas-fir sub-maritime zone: final measurements
Fdi	Barry Jaquish	Trinity Valley range-wide Douglas-fir provenance test: 35 year maintenance and measurement
Hw	Jodie Krakowski	Refining western hemlock seed transfer to optimize productivity for seed sources based on genecology trial results
Lw and Fdi	Barry Jaquish	Lamb Creek range-wide western larch fir provenance test: 20 year maintenance and measurement
Multi species	Greg O'Neill	Assisted Migration Adaptation Trials (AMAT)
Multi species	Jodie Krakowski	Quantifying impacts of climate change on forest health of BC indigenous tree species
Multi species	Phil LePage	Assessment of offsite tree plantations in the Northern Interior Forest Region
Pli	Nicholas Ukrainetz	Assessment of lodgepole pine provenance variation for Mountain Pine Beetle and secondary bark beetle attacks
Sx	Greg O'Neill	Interior spruce seed transfer and assisted migration
System	Sally Aitken	Development of a climate based seed transfer system for changing climates

Table 1. Genecology projects, 2010-2011.

5.0 Genetic Resource Decision Support Technical Advisory Commitee

Lee Charleson

The year 2010-2011 was a year of rebuilding the Decision Support Technical Advisory Committee (DSTAC). No projects were directly undertaken by DSTAC. In related work, the Decision Support staff with the Tree Improvement Branch conceptualized and undertook development of spatially-enabled decision support tools to support seed planning activities such as cone collection and seed inventory management in mountain pine beetle impacted areas. GIS analyses were conducted to integrate seed planning spatial data with the Mountain Pine Beetle Impact Mapping project and geodatabase. The resultant geodatabase includes the following seed planning spatial data sets: orchard and natural stand seed planning zones (SPZ), new western larch climate change seed planning zones, orchard seed planning units, and natural stand seedlots. A series of interactive pdf maps have been developed in 22 priority management units (Timber Supply Areas - TSAs). In addition, opportunity maps were developed to identify potential opportunities related to cone collection within two of the management units (Williams Lake TSA and Quesnel TSA).

The aim of this work is to allow forest managers, stewards and practitioners to conduct Genetic Resource Management (GRM) impact and risk assessments, map current and future tree improvement and seed use opportunities, and determine where forests are vulnerable with regards to genetic adaptation, diversity, and resilience to climate change. The impact of the mountain pine beetle (*Dendroctonus ponderosae*) is equally important when gauging forest health and assessing the implications for seed planning. The results of this decision support project are meant to support both strategic and operational level planning activities; however, these maps are not intended to replace on-the-ground verification; or negate the need to look at current or forecast seed inventories.

A new DSTAC committee was formed in 2010-2011 and a new terms of reference was developed by the committee and approved by FGC.

6.0 Operational Tree Improvement Program

Darrell Wood

The objective of the Operational Tree Improvement Program (OTIP) is to increase the quality and quantity of select seed produced from existing private and Ministry of Forests, Lands and Natural Resource Operations seed orchards.

To meet this objective, a Call for Proposal process is administered each year based on species plan priorities. FGC committees review and rank these proposals based on technical merit, impact, value and costs.

As a result of this work, the Forest Genetics Conservation and Management Program has the ability to meet future seed demands because of key investments in:

- testing
- seed orchard pest management
- seed orchard quality and quantity boosts
- orchard development

OTIP uses a performance measurement system to monitor progress and set reasonable targets for project success. This year, as in past years, orchardists and researchers have responded to this approach and have achieved and exceeded planned targets.

For additional information regarding the budget and key performance indicators, please refer to the FGC Annual Report 2010/11 at: http://www.fgcouncil.bc.ca/FGC-BusinessPlan-2010-11.pdf

6.1 Orchard Projects

6.1.1 Saanich Forestry Centre (WFP)

Annette van Niejenhuis

Western Forest Products (WFP) manages tree seed orchards for forest regeneration programs in the Maritime zone of coastal British Columbia at the Saanich Forestry Centre. Low and high elevation Douglas-fir, low elevation western redcedar, low and high elevation western hemlock, and low elevation Sitka spruce seed orchards as well as yellow cypress hedge orchards are established. As a co-operator in the Forest Genetics Council programs, WFP receives OTIP funds to implement incremental orchard management techniques to deliver quality seed in quantity to the coastal forest regeneration programs.

Low Elevation Coastal Douglas-fir Crop and Orchard Enhancement

Ramet replacement for upgrading and production continued with the establishment of 129 trees in orchards 166 and 405. Current inventory in these orchards is 1,569 ramets with an average breeding value of 18. Grafts for the vacant orchard locations and replacement of poor ramets were maintained. Nutrient management with fertilization of replacement stock for good crown development continued. Plans are in place to address deer management in these orchards.

The 2010 cone crop was small and heavily infested with insects. A very small supplemental pollen management program was implemented. Crop yields were disappointingly low.

High Elevation Douglas-fir Replacement Orchard

Wet weather prevented the establishment of replacement stock in orchard 406. Current orchard inventory is 231 ramets and 16 vacancies; orchard breeding value is 13. Nutrient management for the promotion of good crown development continued. Plans are in place to control deer access to this orchard.

Western Redcedar Orchard and Crop Enhancement

Wet weather in the third and fourth quarters prevented planting of replacement ramets in orchard 198. Current inventory is 308 ramets with a breeding value of 18. Nutrient management of the replacement stock continued.

The 2010 cone crop showed high midge infestation and an average of only 0.5 filled seed on the cone cut, resulting in low yields. Initial observation of the 2011 crop indicated good numbers of females but few male cones.

Low Elevation Western Hemlock Orchard Enhancement

Seed of high genetic worth in storage for western hemlock far exceeds current coastal seed needs, thus we did not manage or harvest the 2010 crop. Orchard maintenance continued; the orchard will be upgraded with roguing and ramet replacement before additional crops will be managed.

High Elevation Western Hemlock Orchard and Future Crop Enhancement

Wet weather precluded planting of replacement ramets in orchard 187. The current orchard inventory is 206 ramets with a breeding value of 11. Nutrient management for early development of the crowns continued. Rabbit damage was detected; vexar tubing was installed on 43 small trees. Plans to control deer access will be implemented next year.

Pollen management was implemented in the small crop in orchard 187. Supplemental mass pollination of breeding value 14 was applied in the first quarter.

Sitka Spruce Orchard and Crop Enhancement

Orchard management in Sitka spruce orchard 172 continued with nutrient management of young stock. Green spruce aphid treatment was applied in the first quarter, and monitoring continued through all quarters. Present orchard inventory is 551 ramets with a resistance breeding value of 86%.

A good cone crop was realized in orchard 172 in 2010, yielding seed for more than 3.5 million plantables. Pollen management was not implemented, but reproductive surveys were conducted.

Yellow Cypress Production Hedges Enhancement

Work continued in the new donor orchard with the establishment of an additional of 1,113 ramets. Current inventory in this hedge orchard is 3,446 donors with a clonal value of 20. These donors represent the top field performers for growth and form that also showed good rootability in cuttings trials. Pests were monitored, nutrients were managed, and crowns were developed for production of cuttings.

6.1.2 Mt. Newton Seed Orchard (TimberWest Forest Company)

Tim Crowder

Douglas-fir

SPU 0106 covers activities in five Fdc M Low orchards: 134, 154, 183, 197 and 404. The management objective is to increase the genetic worth of these orchards from the current 12% to approximately 18% by 2015, and maintain an average annual production of 5 million trees.

These orchards contain a total of 4978 ramets, about half of which are not yet in production. 800 more trees were grafted this year, and 650 trees were established in the fall. An additional 200 were purchased from CLRS as we continue to convert to high density plantings. 328 trees which were too small to plant out were maintained in holding beds.

SMP was required to augment the insufficient pollen cloud on 70 trees of the early and late clones. Both fresh and stored, high breeding value pollen was used and all stored pollen was tested before use.

5 litres of pollen was collected, dried and stored for future use. Internal and external pollen flights were monitored and a contamination rate for foreign pollen was calculated.

Insect pests were monitored and due to high numbers of damaging insects, a spray program of insecticide was carried out.

$GA_{4/7}$ and double overlapping girdles were used to induce a 2011 crop on 750 ramets.

305 large ramets with GW<7 were rogued from the orchards during the winter and the stumps removed to create new planting positions.

Western red cedar

SPU 0205 covers activities in two Cw M Low orchards: 140 and 152. These two orchards are similar in composition and are typically induced in alternating years to provide a steady seed supply.

264 orchard trees were maintained and managed. Monitoring the crop trees for insect pests indicated the need to apply insecticide, so the crop was sprayed.

58 trees were sprayed with GA_3 in July to induce a crop for 2011.

515 grafts from series 3 to 6 were maintained in holding beds awaiting field test results.

25 young high gain trees were planted in positions created by last year's roguing.

Plate 12. Roguing 25 year old Fdc trees with low genetic values.

6.1.3 Saanich Seed Orchards

Lisa Meyer

Orchard Management Operations to Maintain Productivity and Increase Gain in Seed Orchard 181 SM Fdc (SPU 1902)

The objectives of this project are to enhance the seed yield and genetic worth of seedlots produced in orchard 181 by rogueing according to progeny test results, utilizing orchard management techniques to optimize growing stock vigour and crop health, and monitor for and apply pest control if necessary.

The project consisted of identifying and rogueing 378 backward selection ramets as a result of the Fdc breeder's progeny test analysis. 150 new grafts were planted out in the orchard and holding bed.

A total of 717 trees in the orchard including both forward and backward selections were managed through appropriate cultural practices. Graft and ID maintenance were conducted. Foliar nutrient samples were taken and analysed, nutrient prescriptions prepared and fertilizer applied. Soil moisture was monitored and irrigation applied as needed. Top pruning and crown management was conducted on all ramets to initiate potential cone producing sites. Graft unions were surveyed.

Crop management included phenological and bud surveys. Pollen was collected clonally. Due to transplant related stress, the orchard was not managed for cone production and no supplemental mass pollination applied. Production for 2010 was 0.25 l of pollen collected for future use. Pest surveys were conducted. Gemmivia levels were low in 2010 requiring no treatment. Orchard #181, after the additional rogueing of the backward selections and addition of the initial forward selections is predicted to produce seedlots at GW 18. The increase in gain from this orchard meets one of the main objectives of the FGC.

Plate 13. Orchard 181.

Plate 14. Backward selection ramet transplanted.

Upgrade Orchard 175 – Rust Resistance Western White Pine (SPU 0804)

The objective of this project was to upgrade the existing parentively rust resistant white pine ramets at the MFUNRO Saanich Orchard site with the Pw Breeding Program slow canker growth (SCG) and Difficult to Infect (DI) white pine ramets. A total of 467 ramets were in the orchard and bedding beds over the growing season. These were managed using appropriate cultural practices. No new grafts were acquired. Graft and ID maintenance were conducted, foliar nutrient samples taken and analyzed, nutrient prescriptions prepared and fertilizer applied. Soil moisture was monitored and irrigation applied as needed. Crown management was conducted on all appropriate ramets to initiate potential cone producing sites. Pest surveys were conducted and no control measures were required.

Deliverables from this project are established vigorous orchard stock with slow canker growth (SCG) and Difficult to Infect (DI) rust resistant mechanisms that will produce future seedlots of rust resistant seedlings.

Plate 15. Orchard 175.

Plate 16. Orchard 175 close-up.

Orchard Management Operations to Maintain Productivity in High-elevation Western Hemlock Orchard 196 (SPU 2402)

Orchard 196 consists of 28 clones of 210 ramets producing a seedlot of GW 10. Pollen management, pest monitoring and control, and orchard management techniques optimized the growing stock vigour and crop health. Graft and ID maintenance were conducted. Foliar nutrient samples were taken and analyzed, nutrient prescriptions prepared and fertilizer applied. Soil moisture was monitored and irrigation applied as needed. Top pruning and crown management was conducted on all ramets to initiate potential cone producing sites. Graft unions were surveyed. Mortalities were removed. Pollen buds were collected from ramets BW 8 and higher resulting in 0.25 litres of stored pollen to be used for future pollen applications. Deliverables from this project consist of vigorous orchard stock with a production of 5.3 kl of cones resulting in 5.5 kg of seed.

Plate 17. Orchard 196.

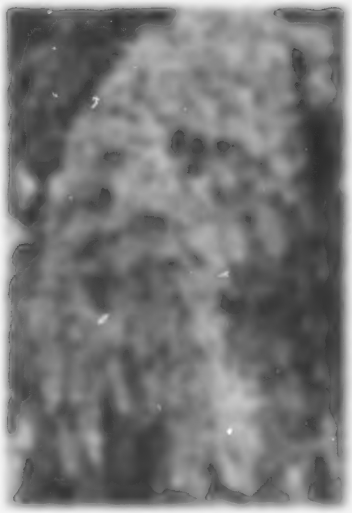


Plate 18. Orchard 196 cone crop.

[illegible]

The purpose of this project was to improve the genetic quality and the quantity of seed crops produced from second generation Douglas-fir Seed Orchard #1059 at the MFLNRO Skeena orchard site through management activities in several project categories.

A total of 1163 ramets in Orchard 1059, and 180 high gain replacement ramets in holding beds were managed using appropriate cultural practices over the growing season. Scion collected in 2009 from orchard stock provided 607 grafts that were planted out in the orchard.

Grade and ID maintenance were conducted. Foliar nutrient samples were taken and analyzed, nutrient prescriptions prepared and fertilizer applied. Soil moisture was monitored and irrigation applied as needed. Top pruning and crown management was conducted on all ramets to initiate potential cone producing sites. Grade ramets were surveyed. Mortalities were removed.

Pollen bulk was collected from ramets with BV 10 and higher resulting in 2 litres of stored pollen to be used for future pollen applications. The pollen has potential to offset the effects of contaminant pollen, provide increased GW of crops produced and increased seed production in early and late clones. Due to transplant related stress, the orchard was not managed for cone production, and no supplemental mass pollination applied. Pest surveys were conducted but no control measures were required.

Deliverables from this project consist of vigorous orchard stock established with potential to maximize production of future crops as well as a moving from orchard with ramets capable of producing crops with genetic worth of 20 or higher by 2015, and 2 litres of stored pollen for future applications.

Plate 14. Orchard 1059.

Plate 15. Orchard 1059 cone crop.

6.1.4 Bowman Seed Orchards

Lassen County

The project was originally designed to upgrade the genetic composition of Douglas-fir seed through rouging management activities and to maintain the seed yields of the seedlots purchased from [illegible].

Cones with a seedling value of 1.2 were rogued from orchards 1305 and 1312. A total of 1407 cones were removed resulting in a change in the current average BV to 1.13. A total of 1111 of yellow cone collected from Arasta were [illegible] of 1.30 or higher and a mix of the field and wind pollen was applied to boost the gain to the yield and bole straight.

Seedlot 9910297 yielded a collection of 10 ml (or 4 GW 10 seed) and a seed yield of 1.2 kg. Seedlot 9910298 yielded a collection of 17.75 bu (collect 4 GW 10 seed per seed yield of 2.9 kg. All orchard trees were maintained through appropriate cultural practices. Foliar nutrient samples were taken therefore was applied for both growing seed and crop maintenance. Cone management and crop pruning completed to increase potential cone sites and graft mature cuttings completed.

Harvest were conducted by Cooperative Resources and Agriculture, and the contract determined that the orchard had a Diazinon calibration but it could not be treated due to pesticide application restrictions. This resulted in lower than expected seed yields.

Future crop management and cone collection of the Bowman Seed Orchard with a Summit Seed Orchard as Ray Curtis and Phyllis Taylor are carrying their [illegible] (see page 34).

Plate 13. Bowman seed orchard site.

Plate 14. Phyllis Taylor and Ray Curtis were co-workers.

Plate 15. Bowman Seed Orchard cone.

[redacted]

[redacted]

In [redacted], [redacted] and [redacted] received [redacted] approval for [redacted] permit to [redacted] [redacted] [redacted]. The [redacted] [redacted] [redacted]

6.1.6 Vernon Seed Orchard Company (VSOC)

Don Gauthier

Operational Tree Improvement Program (OTIP) has once again provided funding for seed orchard production companies to successfully produce improved seed for industry and the Province of BC. With OTIP monies, orchards are able to collect cone and graft, control pest, collect pollen for breeding, as well as a multitude of other vital daily tasks which are required to produce the best seed available.

We consistently achieve the Forest Genetics Council (FGC) directives and we continue to increase the gain, health, production levels and standards of the tree improvement program of British Columbia.

Vernon Seed Orchard has been diligent in fulfilling contract obligations through required reporting mechanisms. This has been very successful in ensuring continued growth and accountability for this vital provincial program.

SPU 1302 Enhancing the Effectiveness of Prince George Orchard 222

Lodgepole Pine is a crucial species for Northern BC and seed production needs to increase through cone development and increased future production levels. VSOC has begun to replace and increase production trees to reach target level demands set out by the FGC and will continue to develop and pursue alternative demands through grafting strategies of forward selection parent trees.

1000 cones were grafted with 2000 cones held over winter for planting in 2010/12 and insect control was carried out for existing orchard trees.

SPU 1206 Pollination and Pest Management in P. contorta Prince George Orchard 236

9 litres of pollen from high gain parent trees were collected for SMP. This pollen will maximize gain in potential seedlots.

Insect control, monitoring and spraying for 4500 trees was completed

SPU 1403 Enhancing Production in Prince George Mixed Tolerant Orchard 211 - White Spruce

Disease monitoring and pest control strategies were used for maximizing our largest crop to date in this orchard. A few families that were identified by the breeder were rogued.

SPU 1206 Pollination and Pest Management for Barkley Valley Orchard 234

Pollen from high gain parent trees was collected for SMP 2500 cones. This pollen will help achieve and maximize gain in potential seedlots.

Insect control, monitoring and spraying for 2930 trees was completed.

SPU 1801 Enhancing the Effectiveness of Central Plateau Orchard 214

Dieback has begun to infect orchard cones. Timing and spray strategies are now in place to effectively prevent further seed loss. Monitoring for this and other pests is ongoing.

SPU 3702, 3703, 4102, 4103, 4301 Increasing Seed Production in Interior Douglas Fir Orchards 231, 232, 233, 225, 226

Douglas fir orchard seed production has started to flourish in the Interior. Warm seasons have been instrumental in larger than anticipated seed yields. Pollen strategies, pest monitoring and inducing crops through $GA_{4/7}$ are part of the success. Control and good orchard management strategies are a must to be successful.

SPU 4202 Pest Management in Prince George High Elevation Orchard 235

Spider mites, adelgids and other pests can seriously affect crop potential. Funding allows orchards to control potential losses efficiently through sprays and monitoring. VSOC had their first harvest of this seed which is in high demand.

SPU 4003/12 Mountain Pine Beetle Control in Lodgepole Pine Orchards

Spraying for control of the Mountain Pine Beetle has reduced dramatically potential tree losses in the interior of BC. Standardized spray schedule applications and trap counts have eliminated virtually all losses. Spray costs are excessive and funding has allowed control measures.

Some key strategies and cost indicators were established in the fall of 2010 by a committee of Industry and Ministry staff. Fixed costs of incremental project items were established in order to make the proposal application, review and approval process more efficient and fair.

Plate 27. Top cross seedlings going to Quesnel.

Plate 28. 2nd gen Se grafts that are going to VSOC for a new 2nd gen orchard.

Plate 29. PB grafts, June 10, 2010.

Plate 30. PB seedlings, June 10, 2010.

6.1.7 Grandview Seed Orchards (PRT Armstrong)

Hilary Graham

Projects 0702, 0721, 1001, 1002, 1007, 210, 4057E35, 0722A and Red Turpentine Beetle

PRT Grandview manages five lodgepole pine orchards and one Douglas-fir orchard, producing seed for the Thompson Okanagan (TO) low elevation and the Nelson (NE) low elevation seed planning units. Three of the Pli orchards are mature (308, 311, and 313), and two are younger orchards (337 and 338) established in cooperation with SelectSeed Company in 2002. The Fdi orchard was also established in 2002 with older grafts and is nearing maturity.

In 2010/11, projects in each of the orchards received OTIP funding for activities to increase the yield and genetic gain of seed produced. These activities included grafting, holding bed maintenance, planting of grafts, roguing, insect and disease monitoring and control, rodent control, crown management, foliar analyses, pollen distribution, pollen collection, flower induction (Fdi only), and supplemental mass pollination (SMP). In addition to the individual orchard projects, two incremental projects were funded for the management of Mountain Pine Beetle, and the Red Turpentine Beetle.

The activities conducted in 2010/11 with the assistance of OTIP funding continue to support our goal of increasing the amount and quality of A-class seed for the Pli NE low, Pli TO low, and Fdi NE low seed planning units. Increasing seed production in these orchards and protecting them from MPB and RTB attack directly supports the FGC's goals by making more genetically improved seed available for use in BC's forests.

Pli orchards

In the spring of 2010, 260 grafts were made to improve the quality of the older Pli orchards 308, 311, and 313. These grafts were maintained in pots in a holding area until September when they were planted out into a field bed for overwintering. Because of a recurring problem with June beetle larvae feeding on the roots of newly planted grafts in the orchards, we decided to delay planting in 2010. While dealing with the June beetle problem, we also delayed roguing for the season.

Pollen management activities began in early May with pollen collection and the distribution of natural pollen using an orchard air-blast sprayer. The SelectSeed Pli orchards 337 and 338 received four SMP applications to supplement their smaller natural pollen clouds. Pollen was collected from the mature orchards 311 and 313 which have an abundant pollen supply. Shedding pollen was collected with backpack vacuums by clone. We collected 3 litres of pollen for the TO low and 1 ½ litres of pollen for the NE low for use in future years.

Foliar tissue samples were taken to determine the appropriate fertilizer mix for spring and fall applications. Throughout the season, we monitored all Pli orchards for insect, rodent, and disease problems. This ensured that measures were taken to protect ramet health and developing cones. A single insecticide spray was applied to control *Leptoglossus* seed bug in orchard 338 but no sprays were required in the other Pli orchards due to low populations of *Leptoglossus*. Poison baits were used to control rodents feeding on tree roots, and Sequoia pitch moth larvae were removed manually. In the fall of 2010, pruning was done in the larger orchards to open up the crowns, restrict ramet height, and maintain tractor access down the rows. Approximately 1/3rd of each orchard (Pli 308, 311, and 313) is pruned each year to maintain a more consistent cone supply from year to year.

All projects were completed as planned in 2010/11. The 2010 cone harvest yielded seed volumes far in excess of expectations. In the Pli Thompson Okanagan Low, we collected 55 kg of seed with the potential to produce 10.1 million seedlings. In the Pli Nelson Low, we collected 19.1 kg of seed with the potential to produce 3.52 million seedlings.

Crop Statistics (0722A)

As part of a collaborative project headed by Michael Carlson at the Kalamalka Forestry Centre, data was collected from orchards 311, 313, and 338 to assess seed orchard seed set and productivity. This data, collected at all interior Pli orchards using a standardized method, will contribute to our understanding of seed-set in the different Okanagan Seed Orchards. This will ultimately lead to recommendations for orchard management practices that will improve seed production.

Fdi orchard

Because of the limited supply of natural pollen, we applied stored pollen to receptive flowers four times (SMP). At the same time, pollen for future use was collected from ramets within orchard 321 that had a heavier pollen load. With only a moderate amount of pollen available in 2010, only one litre of pollen was collected, processed, and put into freezer storage.

Throughout the season, we monitored the Fdi orchard for insect damage to the developing cone crop. An insecticide spray was applied early in the season to protect the crop from *Dioryctria* (fir coneworm), which has caused substantial damage to previous cone crops. Prior to cone harvest, fresh *Dioryctria* attacks were showing up in the crop and a second insecticide spray was required. With two well-timed insecticide sprays there was very little damage evident at the time of cone harvest.

For crop induction, we applied gibberellic acid (GA) to 600 ramets by stem injection. Also, all larger ramets were drought stressed during bud initiation to promote the formation of reproductive buds for the 2011 season.

The 2010 Fdi crop met the expected target with 18.05 kg of seed extracted (892,000 plantables).

Grandview Seed Orchards Incremental Projects

Mountain Pine Beetle - Pli Ramet Protection

In 2010 we continued with a proactive approach to MPB control, applying a prophylactic insecticidal bole spray applied to approximately 5500 susceptible ramets in the five Pli orchards in advance of any beetle flight. In addition, MPB pheromone traps were set up around the PRT Armstrong site to monitor the presence and abundance of beetles in the area. Trap monitoring indicated that the orchards were exposed to moderate populations of beetles during the summer of 2010. However, monitoring of orchard ramets throughout the season showed no MPB attacks on any of the treated orchard ramets. However, a number of windbreak and landscape Pli and Py trees on the PRT site which were unprotected by the spray were attacked and killed during this same period. The presence of beetles and absence of damage in the orchards indicates that the single prophylactic spray was again very effective in protecting our orchards.

Red Turpentine Beetle (RTB)

In 2009 the Pli orchards at PRT suffered numerous RTB attacks (over 350 ramets affected and over 30 ramets killed by the beetle). Ramets with a bole diameter of as little as 3 cm were being attacked and killed. As a result, in 2010, a project was funded to monitor and remove any beetles, and to treat smaller diameter ramets with an insecticidal bole spray. The RTB spray treatment targeted those smaller diameter ramets not already protected by the MPB bole spray. In addition, RTB pheromone traps were set out on the site to determine the population levels around the orchards. Trap catches revealed a peak flight period in early May, which coincided with the bole spray application. Duff and grass was removed from around the base of the boles to facilitate monitoring as the beetles tend to attack at soil level and signs of damage can be difficult to see. Throughout the season all ramets were monitored for beetle damage on a weekly basis. Where evidence was found, beetles were physically removed. In 2010, over 200 ramets were attacked by RTB and 40 ramets died as a result of damage suffered in 2009 and 2010. Constant monitoring and the removal of beetles soon after attack prevented more extensive mortality. The dead ramets were removed from the orchards.

Plate 31. Digging for red turpentine beetle.

Plate 32. Collecting cones for Crop Statistics (Project 0722).

Plate 33. PRT cone harvest crew 2010.

6.1.8 Eagle Rock Seed Orchards (Tolko Industries)

Greg Pieper

Five orchards are managed by Tolko Industries for the Thompson Okanagan seed planning zone. Three of these orchards, two interior spruce and one lodgepole pine, are SelectSeed funded orchards. The four projects funded by the Operational Tree Improvement Program aid in improving the quality and quantity of seed produced for the forest community. In 2010, Eagle Rock produced seed for 4.3 million lodgepole pine seedlings and 30 million interior spruce seedlings for reforestation in the Thompson Okanagan region.

SPU 16 Thompson Okanagan Pli High, Orchards 310 (Tolko) and 339 (SelectSeed), Project 1601

- Male bud and phenology surveys were completed to determine clonal contribution, timing of pollen shed and female receptivity for each clone.
- When surveys indicated optimal receptivity, supplemental mass pollination was completed with the aid of a mist blower and helicopter.
- Pocket gophers were controlled using bait.
- Weekly pest monitoring was completed for *Leptoglossus* and five sprays were required for control.
- *Synanthedon* and *Dioryctria* were manually removed.
- Lateral branches were pruned in orchard 310 to increase access for orchard equipment.
- Foliar samples were collected and sent to Pacific Soils Lab for analysis. Lab results aid in determining fertilization requirements for the following season.
- Phenology and cone collection was completed for OTIP0722. Information and samples were sent to Kalamalka Seed Orchard for processing.

SPU 28 and 30 Thompson Okanagan Sx Low, Orchard 342 and Sx High, Orchard 343, Project 2801

- Due to the sizable cone crop in spruce, induction was only completed on a select number of trees that were healthy and had no cone load.
- Routine monitoring for pests such as *Dioryctria*, Adelgids, *Pissodes strobi*, and *Oligonychus ununguis* was completed. Control for *Dioryctria* was required after pollination and leaders containing *Pissodes* spp. were removed to decrease the population.
- To optimize seed set, SMP was completed with the aid of a mist blower to stir the pollen throughout the orchard.

Incremental Projects
Mitigate the Effects of the Red Turpentine Beetle

- The duff was removed from around each tree to monitor for attacks and make subsequent monitoring more efficient.
- Weekly monitoring of all ramets for attack symptoms, dying trees or feeding at soil line, was completed.
- Treatment with a 2% Sevin spray on the bole of each tree was done to prevent new attacks.

Mountain Pine Beetle Management

- All ramets in orchard 339 were administered one application of 2% Sevin to the boles of the tree in mid June to prevent attacks.
- Routine visual monitoring for evidence of mountain pine beetle attacks on the boles of orchard ramets was completed. No attacks were observed in 2010.
- Pheromone traps were placed in four locations (2 traps per location) around the orchard perimeter. Trap catches were monitored weekly throughout the growing season. Populations have declined from previous years.

Plate 34. Eagle Rock Seed Orchards Overview.

Plate 35. Stirring pollen with the aid of a helicopter.

6.1.9 Prince George Tree Improvement Station (PGTIS)

Rita Wagner

SPU 1203, 1802, 1702

Activities are aimed at increasing the quantity and quality of lodgepole pine seed from Orchard 220 (Prince George low planning zone), Orchard 223 (Central Plateau low planning zone) and Orchard 228 (Bulkley Valley low planning zone).

Five Operational Tree Improvement Projects were conducted at the Prince George Tree Improvement Station in 2010-2011.

Phenology surveys were completed to keep track of receptivity periods which can vary considerably from year to year. Pollen flights were monitored. Outside pine pollen flight is basically non-existent due to the devastation caused by the mountain pine beetle.

October foliar samples were taken for nutrient analyses. Fertilizer applications were increased ensuring maximum cutter health.

Branch damage caused by hydraulic lifts, heavy & wet snow loads and strong winds required tree maintenance. Surveys for western gall rust, *Elytroderma* needle cast, *Lophodermella* pine needle cast, *Zelleria* pine needle-sheath miner, *Cecidomyia* pinch midge, and various other insects were completed. *Cecidomyia* and *Zelleria* caused considerable flower abortion, and spot surveys were conducted to keep track of severity of outbreak. Topping of 30% of orchard trees was completed.

Lindgren traps were set up throughout the site to monitor secondary bark beetle flights (mainly *Ips*). As in 2009, mountain pine beetle activity in the Prince George area continued to drop in 2010.

Despite some rogueing and three consecutive excellent crop years, our three lodgepole pine orchards produced the second largest crop in 2010. The three provenance orchards yielded 63,388 kg of seed, the equivalent of approximately 15.28 million potential seedlings with a genetic worth of 0%.

Some squirrel trapping was required to avoid seed loss and loss of potential cone sites.

SPU 1412 & 4004023

Management of interior spruce clone banks at the Prince George Tree Improvement Station is designed to ensure the availability of scions to replace existing orchard ramets or develop new orchards to boost productivity and gain. The Interior Spruce Clone Banks at the Prince George Tree Improvement Station provide vital support to the orchard and tree breeding programs in BC. The clone banks are a centralized source of scion material for the grafting of new and improved seed orchards. They contain the only copy of many of the interior spruce parent tree selections found in seed orchards and breed arboreta.

The following activities were carried out:

- Maintenance of 250 grafts planted in 2008.
- Tagged 100 small ramets.
- Replaced unreadable tags on 120 ramets and moved 400 tags to prevent girdling.
- Planted 100 grafts into various clonebanks.
- Updated clonebank data base and created 1-page field maps for each clonebank.
- Topped 920 trees to a height of 3.5 to 4.0 m.
- Pruned bottom branches up to 0.5 to 1.0 m in the Ft. Nelson and Quesnel Lakes Expansion clonebanks, including mowing of tags.

To ensure good ramet health the following management activities were carried out in the 12,000 tree clone banks: inventories, irrigation maintenance, fertilization, mowing and weeding/brushing, label replacement and foliar sampling. Extensive headland mowing was necessary to control weeds and prevent brush from moving in. Insect (root collar weevil and spruce leader weevil) and disease monitoring was carried out to keep abreast of potential pest problems.

Plate 36. Cone collecting, and biggest crop from three permanent orchards.

Plate 37. Planting Queretaro-Luiker Ignacio CB.

Plate 38. Ane Kelly's CP (22) irrigating.

Plate 39. Building 126 finishing recovers.

Plate 40. Ian Maryland rock pitching in Building 126.

[redacted]

[redacted]

[redacted]

Work was limited to one of the seed orchards, the research plantations, and to help maintain and control the Mountain Pine Beetle infestation in Manitou in 2006.

[redacted]

The West Kootenay Dirkson Mid and High elevation spruce orchards had 147 replacement grafts maintained in the bedding area. The orchards were surveyed for insects and disease, three rust hosts (3 *Pinus* spp. overstory/graft), and thirteen weevil (*Pissodes strobi*) attacked tops were removed, rodents were baited, and the orchards were sprayed for white pines and *Diprionids*.

Orchard 161 Dirkson mid had a crop of 74.8 kg yielding 51.23 kg and orchard 162 Dirkson high had a crop of 65.0 kg yielding 147.39 kg.

[redacted]

Orchard 92, comprised of parents selected in tree program was for Western Gulf Base Resources, was planted in the fall of 2005. The 93.98 ramets were monitored for insects and disease and baited for rodents. About 10 to 15 trees died from rodent chewing, the rest survive, mostly throughout the first winter and early spring. The field had previously been an unused hay field and so rodent control had been done as the initial population was quite high when the orchard was planted.

[redacted]

The white pine orchard 89009 was monitored extensively because of the mountain pine beetle. Jet pine cone moth, and *Diprionid* swabbing in 42 crop counts being done over the season, plus many visual surveys. The orchard was sprayed with Avaunt 75 DF in late May for the mountain pine beetle using two orchard lifts fitted with spray guns. No trees were attacked. The crop was 39.0 kg and yielded 29.2 kg.

[redacted]

The three spruce orchards for the Bulkley Valley Low were sprayed for spruce cone rust, spruce budworm, and *Diprionids*. Twelve weevil attacked tops and two rust hosted trees removed. The 249 replacement grafts were maintained in the bedding area.

The crop was 39.8 kg and yielded 63.59 kg of seed.

[redacted]

In the spruce orchards for the Peace River Low and elevation zones 0.0 to 0.0 the 3779 trees were monitored for insects, disease, and rodents. Orchard 212 was sprayed for spruce budworm, spider mites, cone rust, and *Diprionids*. Orchard 213 was sprayed with BtK for spruce budworm. A total of 66 weevil damaged tops were removed and the orchards were baited extensively for rodents. The 109 replacement grafts were maintained for orchard 213.

The crop in orchard 213 was 123.2 kg and yielded 107.3 kg.

[redacted]

The on-site research plantations were also monitored for insects and disease and baited for rodents. The evergreen spruce plantation was sprayed for spruce budworm. The *Abies* garden was maintained and white pine seedlings were inventoried in September. The white pine Age Related Resistance Trial (ARRT) was planted at its final spacing and was treated for cankerous in June. The rare white plantation was removed in 2005 were calibrated and recorded. A lodgepole pine plantation was removed in the summer to reduce the soil suppressive beetle populations and a lodgepole pine demonstration, a hybrid report plantation, and one birch plantation were removed in the fall.

[redacted]

Extensive monitoring was done for the mountain pine beetle and orchards 165 (Pli) and 166 (Pla) were sprayed with Avaunt 75 DF in late May. The beetle crops were checked once a week and the crop counts peaked the third week in July with a few counts being over 100. This was down considerably from 2005 when many of the crop counts were in the 1000s when the crops were being checked twice a week.

[redacted]

[redacted]

[redacted]

6.2 Technical Support Programs

6.2.1 Increasing Quality, Genetic Gain, and Quantity of Yellow Cypress Cuttings

Mark Griffin, John Ogg, Craig Ferguson and John Russell

SPU 1111

Introduction

This project involves increasing the quantity and quality of high-value yellow cypress cuttings for the coastal program. Objectives include:

1. provide the cultural treatments required to improve hedge production.
2. enhance hedge composition by replacing lower-genetic-value families and clones with newly tested, improved clones.

2009/10-2010/11 Highlights

Planting of hedges occurred in June 2010. The media for the greenhouse-grown container planted donor plants contained 60% 10-5-15, augmented bi-weekly with applications of hi-ed.

In the autumn of 2010 there were 9600 donor plants in the operational hedge. The estimated number of cuttings available from this hedge is currently estimated at 173,000 plants. Roguing has been deferred until 2011. 2009 cuttings from series 2 were transplanted from 100% into 625 blocks and 2009 cuttings from series 1 were potted in an effort to maximize increased growth rate while maintaining genetic variability.

In an effort to increase the rooting success of the clones in the hedge, some 2009 cuttings were set to test hedge root ability. A sampling of every clone from series 1&2&3 in the greenhouse was set to test each clone's propensity to root. Clones will be evaluated and poor performing clones may be removed from production. Clones are being evaluated annually on an ongoing basis.

In late 2010, some 20,000 cuttings from the operational hedge were supplied for production to reforestation nurseries.

6.2.2 Estimating Pollen Contamination in Coastal Seed Orchards

Joe Weldon

SPU 0111

Contamination levels in two coastal Douglas-fir orchards (2010) were 46.1% and 16.8% for Western Forest Products (WFP - 166) and TimberWest (TW - 183), respectively. These values are higher than expected. 2009 was the highest recorded for the last six years. Orchard receptivity period in both orchards was the same this year (April 15-25). Orchard pollen loads for the receptivity period were considerably different for the two orchards. Table 4 shows the pollen load for the receptivity period of the orchard (ORC 30 PL) and regional monitors (REG PL). The biggest difference between 2009 and 2010 is the orchard pollen load for WFP which in 2010 was about 67% less than in 2009. Regional pollen loads were the same for both orchards in 2010 (same receptivity periods) but differed substantially in 2009 (different receptivity periods).

Table 4 also shows contamination values determined from DNA paternity analysis (2005-2007) which agree well with pollen monitoring data based on a simple ratio of pollen load from regional to orchard values summed over the receptivity period of the orchard. Because 2009 values were the highest recorded for both WFP and TW, Dr. Tonsey El-Kassaby is currently determining contamination values from DNA analysis.

The other important feature in 2010 was the protracted receptivity period. This allowed the calculation of the orchard adjustment factor (OAF) according to the green book protocol (Woods et al. 1996). Table 5 shows the range of the OAF for both the mean of three Regional (-R) monitors and one orchard (OUT (-O) monitor (used by the orchards for their regional pollen load calculations). Table 5 also shows the adjusted Regional and Out pollen load values with their corresponding contamination values. Although not an objective for OTIP 0111 (2010), corresponding pollen load and contamination values for the MFLNRO orchard 139 are also included.

The OAF values shown in the above table were all greater than 1 for Regional monitoring and only WFP OUT monitor data produced an OAF value less than 1. In my opinion, the OAF factor is not useful since it is very dependent on which dates are used and has not improved our estimates of contamination when both pollen monitoring and paternity data are compared.

Table 4

	WFP						TW		
	2005	2006	2007	2008	2009	2010	2008	2009	2010
REG PL	4.6	6.7	24.6	7.3	39.1	12.7	3.2	23.0	12.7
ORCH PL	98.3	54.6	114.6	48.9	85.4	27.5	28.6	67.8	63.7
% Contamination									
PM	4.8	12.5	21.5	14.9	45.8	46.1	11.2	34.0	19.9
DNA (Stoehr)	9.7	11.7	19.3	na	na	na	na	na	na
DNA (El-Kassaby)	10.5								

Table 4. Coastal Douglas-fir orchard pollen contamination values based on the ratio of regional pollen load (REG PL) to orchard pollen load (ORCH PL) in Western Forest Products (WFP orchard 1662) and TimberWest (TW orchard 1663) for the years 2005 to 2010 (WFP) and 2008-2010 (TW). Contamination values based on paternity analysis by Stoehr and El-Kassaby are shown where available.

Table 5

	Pollen Load		no OAF		OAF	
Orchard (Orch)	6-Weeks	Recap	%Contam-R	%Contam-O	%Contam-R	%Contam-O
WFP	31.9	27.5	46.2	37.8	79.6	18.5
TW	75.3	63.7	19.9	22.0	95.7	33.9
MFLNRO	33.4	12.0	38.3	45.0	61.3	61.3
Regional (R)	6-Weeks	Recap	OAF per Protocol		Adjusted-REG	Adjusted-O
WFP	20.3	12.7	2.0	0.4	25.4	5.1
TW	20.3	12.7	4.8	1.7	61.0	21.6
MFLNRO	20.3	4.6	1.6	1.6	7.4	7.4
Orchard-OUT (O)	6-Weeks	Recap				
WFP	20.8	10.4				
TW	22.3	14.0				
MFLNRO	14.3	5.4				

Table 5. Calculation of Douglas-fir contamination from orchard (ORCH) and regional (REG) data with and without the Orchard Adjustment Factor (OAF). Contamination was also calculated using each of the three orchard OUT data.

6.2.3 Collection of Crop Statistics for Interior Lodgepole Pine Orchards

Final Report OTIP 0722 - 2010 Summary

Prepared for Michael Carlson
by Joe Webber

The full report is available at this url.

http://www.fgcouncil.bc.ca/2010_OTIP_0722_final_summary.pdf

Executive Summary

Seed yields (filled seeds per cone) from north Okanagan (NO) orchards have not met expectations compared with seed yields routinely realized at Prince George (PG). This report summarizes the 2010 data collected for eight of the original 12 NO orchards, six new expansion NO orchards and two PG lodgepole pine seed orchards. It also provides a summary of annual statistics for cone and seed yields from eight of the original 12 orchards over the period of 2006 to 2010.

In previous years, higher seed yields per cone but fewer cones were observed at PG. However, in 2010, PG orchards produced similar number of cones per tree compared to the eight NO orchards and six expansion orchards. The PG orchards produced more seed per cone (20.6) than the eight older orchards (11.5) and six new orchards (8.3). Similar values were observed for the total number of seed per cone. The number of cones per tree from KAL 230 has consistently been the highest over the five year period with seed yields similar to those observed in PG.

The number of seed per ramet between NO and PG was 3217 and 5982, respectively. If NO orchard 230 were excluded, the difference between NO and PG would be even greater. The mean number of seed per tree from the eight old and six new orchards was 4120 and 2186, respectively. Both PRT 338 and Tolko 339 produced over 3000s seed per tree which was similar to the mean number for all NO orchards (excluding KAL 230).

Bagging effects were also monitored in 2010. On average, bagged cones produced about 5 seed per cone more than unbagged cones (15.9 versus 11.0 filled seed per cone). Over the five years observation, the loss of seed from unbagged cones ranged from about 2 to 5 filled seed per cone. The greatest loss of seed occurred at Kalamalka. There was no seed loss from unpegging cones at PG.

In 2010, an attempt to determine when seed losses from bagging occurred was repeated. In this trial, cones were exposed for a two week period beginning late April and continuing through late August. Seed yields for each of the 9 exposure periods were then compared to seed yields from cones always protected (bags always on) and cones never protected (bags always off).

Substantial seed losses occurred late in the season. Seed losses were largest at KAL, less so at PRT and least at VSOC. Debate continues about the cause of this seed loss. One side of the argument suggest the losses are too large to be caused by insects alone. However, it is difficult to suggest a mechanism by which a fully formed embryo in July disappears in August. Since inferences on timing of seed losses can not be made from one year data, this experiment is intended to be repeated in 2011.

We continue to see about 10-15 fewer seed per cone from NO orchards compared to PG orchards. If bagging effect accounts for about 3-5 seed per cone, we still can not account for about 5-10 fewer seed per cone from NO orchards. The only way we can understand how embryos from post-dormant first year cones are lost in the second year cone is to complete comprehensive developmental studies.

7.0 Extension Technical Advisory Committee (ETAC)

Diane Douglas

This past year was a year of cooperative projects and funding participation!

Workshops

ETAC members participated in the development and delivery of the following workshops.

International Cedar Symposium "A Tale of Two Cedars Symposium" May 25-28, 2010
The organizing committee included Barb Hawkins (UVic), Jodie Kradowski, John Russell and Diane Douglas (MFLNRO), Paul Hennon, USFS, Alaska and Connie Harrington, USFS, Washington state. More than 60 people attended the full workshop with 9 additional people attending the silviculture session.
On-line conference proceedings are at:
http://treesearch.fs.fed.us/pubs/36731
Hard copies are available at: http://www.fs.fed.us/pnw/publications/gtrs.shtml

Deer Browse Resistant Cedar Workshop (John Russell) – June 2, 2010 CLRS. 50 people attended

Coastal White Pine and Sitka Spruce Deployment Workshop October 19, 2010 This was managed through the Coast Region Implementation Team (CRIT) and Campbell River Forest District with 30 people in attendance.
http://www.for.gov.bc.ca/rco/stewardship/CRIT/index.htm http://www.for.gov.bc.ca/rco/stewardship/CRIT/docs/PwSsCoastannounceOct.pdf

UBC/Coastal Technical Advisory Committee Extension meeting held at UBC - November 23, 2010 – student presentations. (organized by Sally Aitken and Annette van Niejenhuis)

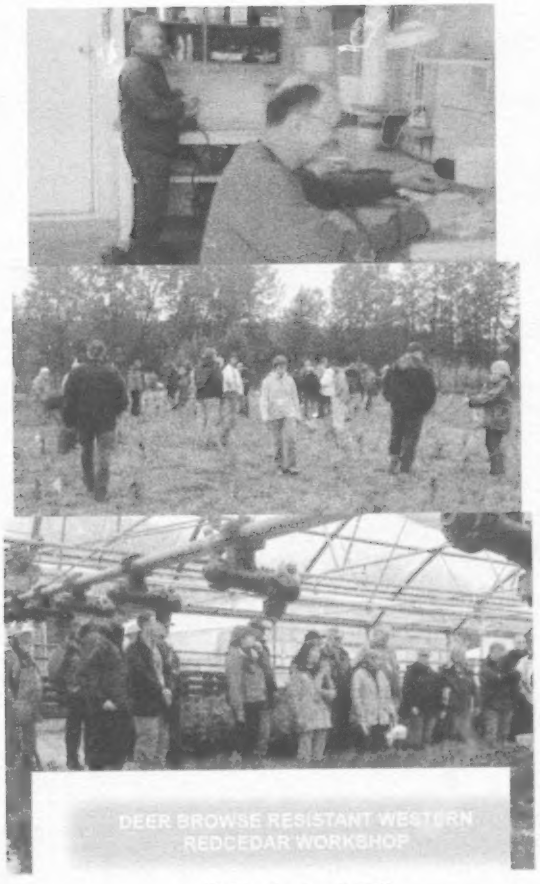
Coastal Breeders Biennial Extension Meeting & Field Trip, Victoria – November 30 & December 1, 2010.

On-line presentation by Laura Gray's, December 20, 2010
"An Update on Matching Planting Stock with Environments for Reforestation Under Climate Change"
http://www.for.gov.bc.ca/ftp/HTI/external/!publish/Laura_Gray/

Publications

A number of extension publications and posters were completed.

- PMTAC - Pest Leaflets http://www.fgcouncil.bc.ca/doc-pestmaninfo.html
- Verifying genetic gain estimates in coastal Douglas-fir in British Columbia, Extension Note 104 – Michael Stoehr et al. https://www.for.gov.bc.ca/hfd/pubs/Docs/En/En104.htm
- Seedlot Genetic Worth Values Verified for Coastal Douglas-fir at age 12, FGC Fact Sheet 2 – Jack Woods et al. http://www.fgcouncil.bc.ca/Factsheet2-DFir-13Apr11-Web.pdf
- Forest Genetic Conservation Posters – 5 posters prepared - Jodie Krakowski http://www.for.gov.bc.ca/hfd/pubs/Docs/P/P085.htm
- Whitebark Pine Background Paper - Don Pigott http://www.fgcouncil.bc.ca/Factsheet1-WhitebarkPine-27May10-Web.pdf
- Fungal Assay Poster - Dave Kolotelo http://www.for.gov.bc.ca/hti/publications/tsc/Fungal_Assay_Poster_sm.pdf
- TICtalk http://www.fgcouncil.bc.ca/TICtalk_September_2010.pdf



Wednesday, June 2, 2010
Cowichan Lake Research Station (map attached)

Accommodation available at Cowichan Lake Research Station. http://www.for.gov.bc.ca/hre/forgen/cltrs_cc.htm

Field tests of deer browse-resistant seedlots have produced encouraging results. Trees have been selected that are "not-preferred" (putatively resistant) by blacktail deer based primarily on needle monoterpene content, which is highly heritable in western redcedar. However, deploying only "resis material may alter deer behaviour if there is no alternative food source available. Preliminary deployment trials involving mixtures of needle monoterpene levels through genetic selection and stocktype have been encouraging. The next step is to test this material in larger-scale operational settings to determine optimal mixtures of preferred and not-preferred seedlings across different site types and silvicultural treatments. To achieve this goal a co-operative approach is necessary involv growers, field foresters and researchers.

Agenda:

0800 **Breeding for browse resistant populations**
John Russell, RBI, MFR
Issues surrounding deployment of mammal resistant planting stock
Bruce Kimball, USDA/MONELL Sensing Lab, Philadelphia, PA
Opportunity to phone in for these presentations. (call info TBA)

1030 **Tour of deer resistance research at CLRS**

1200 Lunch at the historic cookhouse

1300 **Deployment research with browse resistant *Eucalyptus***
Julianne Wapstra-O'Reilly & Brad Potts, U. of Tasmania, AU(presented by J Ri
Deployment research with browse resistant western redcedar
John Russell and Bruce Kimball
Discussion on developing a co-operative to support operational deployment trials.
(Opportunity to phone in for presentation and participate in the discussion TBA

1530 Depart for tour of deer preferred and not-preferred seedlings at Holt Creek field site

1700 Conclusion

There is no charge. Please register at:
http://www.fs.fed.us/pnw/olympia/silv/Cedar/symposium.html or contact:
John Russell, John.Russell@gov.bc.ca, 250.749.6811 ext. 26 or
Diane Douglas, Diane.L.Douglas@gov.bc.ca, 250.356.6721

Plate 53. A Tale of Two Cedars and Deer Browse Resistant activities.

ENCOURAGING DEPLOYMENT OF WESTERN WHITE PINE AND SITKA SPRUCE IN THE COAST FOREST REGION. A LOOK AT RECENT ADVANCES IN PEST RESISTANCE

Campbell River
0800 - 1630 October 19 2010

Location: Campbell River Area (District office and local area field sites)

Purpose: Provide operational foresters with the latest information regarding operational performance of rust-resistant western white pine and weevil resistance Sitka spruce on the British Columbia coast.

Target Audience: Operational Foresters and silviculturalists with an interest in managing for western white pine and Sitka spruce on the BC Coast.

Objectives:
- Review rust-resistance mechanisms and breeding program for rust resistant white pine
- Review weevil-resistance mechanisms and breeding program for weevil resistant Sitka spruce
- Review identification, history and impact of both white pine blister rust and spruce weevil
- Present and discuss data on the performance of both rust-resistant white pine and weevil resistant Sitka spruce
- Review weevil risk hazard rating methods and their application
- Review blister rust hazard rating methods and possible application
- Discuss opportunities for increased use of western white pine and Sitka spruce on the BC coast
- Discuss management recommendations for the use of rust-resistant white pine and weevil –resistant Sitka spruce

Registration:
There is no registration fee for the workshop. Please bring a bag lunch.

Respond to: Craig Wickland Craig.Wickland@gov.bc.ca or
Scott Dunn Scott.Dunn@gov.bc.ca with your name and contact information if you would like to attend the one day workshop.

Registration will be confirmed and an agenda sent by e-mail to participants approximately 1 week prior to workshop.

Ministry of Forests and Range

Plate 54. White pine and Sitka spruce field day.

8.0 Seed Orchard Pest Management

Jim Corrigan

The Seed Orchard Pest Management Subprogram supports research, extension activities, and orchard-level pest management to increase orchard yields of high quality seed. Research and extension are handled by the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), Tree Improvement Branch.

Dr. Ward Strong leads the research component. Jim Corrigan delivers extension services. Seed orchard personnel handle pest management activities in the seed orchards. The Pest Management Technical Advisory Committee (PMTAC) guides investments and activities, and is comprised of members from MFLNRO Tree Improvement Branch, the Canadian Forest Service, private seed orchards, universities, and the Forest Genetics Council. Research plans and budgets are established through an annual process of proposal development and discussions by the PMTAC. This fiscal, the PMTAC administered projects on conifer seed bug, fir coneworm, novel pesticides, a cone and seed insect field guide, lab and technical research support, as well as interior cone and seed pest management extension operations (previously administered through the OTIP subprogram). Projects are summarized in Table 6.

Project	Species primarily impacted	Progress
Contarinia oregonensis Host-finding mechanisms	Fd	Due to late delivery of funding, this project was restricted to purchase of equipment required for future studies.
Fir coneworm (*Dioryctria abietivorella*) Reproductive biology	Fd, Sx, Lw, Pw	This project, in collaboration with University of Alberta, was wrapped up with funding to finish data analysis, writing, and graduate student thesis submission.
Conifer seed bug (*Leptoglossus occidentalis*) Seed bug dispersal, host selection, and abundance study.	All Pinaceae	Seed bug dispersal, host selection, and abundance study. (University of Northern BC (UNBC); UBC – Okanagan). Data collection for this project, in collaboration with UNBC, was wrapped up. Data analysis as well as writing of reports and M.Sc. thesis continues.
Cone and seed insects: Host-finding mechanisms	All Pinaceae	Continuing studies in collaboration with Simon Fraser University investigated the interaction of visible light, infrared radiation, and host shape in host finding by *Leptoglossus occidentalis*, *Dioryctria abietivorella*, and *Contarinia oregonensis*.
Cone & seed insect control: Trials of novel pesticides	All species	Continuing studies of foliar sprays from 2009, this project selected the most promising pesticides for further testing in 2010.
Cone and seed insect field guide	All species	The field guide has been completed with 14 Pest Management Leaflets produced. These are available at http://www.fgcouncil.bc.ca/doc-pestmaninfo.html
Research lab and technical support	All species	Funding was provided for on-going lab operations and technical assistance in support of research activities.
Interior pest management extension operations	All interior species	Funding provided on-going extension support to Interior seed orchards and natural stand seed production personnel.

Table 6. Pest Management TAC projects..

Plate 55. Pesticide trial - Mario Lanthier's employee applying pesticides for the pesticide trial. (photo Mario Lanthier)

Plate 56. Bug dorms - colonies of conifer seed bugs for the UNBC dispersal and host selection study. (photo Ward Strong)

Plate 57. Seed X-rays - setting up seeds for X-raying to determine insect damage. (photo Ward Strong)

Plate 58. Douglas-fir cones damaged by fir coneworm, *Dioryctria abietivorella*. (photo: Jim Corrigan)

Plate 59. *Eucosma sonomiana* adult on white pine needles. (photo: Jim Corrigan)

Plate 60. (Centre) Adult pitch moth, *Synanthedon sequoia*, just after emerging from pitch mass. (photo: Jim Corrigan)

Plate 61. Larvae of the black cutworm, *Agrotis ipsilon*, found under a coconut after attacking a white pine seedling. (photo: Jim Corrigan)

Plate 62. Faye Klassen applies fabric wrap to a lodgepole pine ramet to protect it from feeding damage caused by the pitch moth, *Synanthedon sequoiae*. (photo: Jim Corrigan)

9.0 Retired Friends and Colleagues

Helga Mohl

Helga Mohl retired in October 2010. She started with the Ministry in May 1982 working in seedling physiology lab at the Glen Road Research Station (nowadays known as Research Branch Laboratory or RBL). Later she moved to the container and orchard program, where she was involved in controlled pollinations, herbicide, and pruning studies, as well as stock maintenance. Helga then worked with Sylvia Dhiwadkar on seedling frost hardiness and UV-B tolerance, until another Ministry re-org, after which she ran the Molecular Genetics lab at RBL. Her ability to quickly learn the complicated molecular DNA techniques and her attention to details during any trouble shooting allowed her to efficiently gather large amounts of DNA data for fingerprinting and genotyping of seed orchard clones. This work resulted in data that formed the basis of several peer-reviewed articles, which is a direct reflection of her high quality of work. More recently, Helga worked in the Analytical lab with Clive Dimmock's group.

Helga moved with her husband Ron, dog Lobo and cat Lucy to Pender Harbour (near Sechelt) where she enjoys hiking, cycling, paddling and boating her wine expertise. (Helga passed the third level to be a professional sommelier in 2009). So, when you visit her and Ron make sure you don't bring the cheapest wine ...

Helga's many contributions to Forest Genetics Research and Tree Improvement are much appreciated.

Photo 9.1. Helga Mohl.

Keith Lyle

After 33 years with the Forest Service, Keith retired from the Skimikin Seed Orchard as the Seed Orchard Supervisor on February 28, 2005.

After Keith graduated from BCIT in 1977, he worked for the BCFS Engineering Division, establishing the high water mark for the Bowron-Ike Dam reservoir, then up to Houston surveying the Morice River Forest Road, along with a winter stint in the Victoria office. In May 1978, Keith was offered a job at the newly established Skimikin Seed Orchard. In June 1978, this involved selecting spruce parent trees for the rest of the summer and fall and then switching to scion collection in mid-November. In mid-March 1979 he packed the snowmobile and put away the rifle and began helping organize for spring planting. At this time there were five seed orchard staff at Skimikin: Maurice Albrecht, Gary Clarke, Keith Cox, Madeleine Dunleavy, and Arne Ericson.

In 1979, Keith married Noelle, his wife of 29 years and counting. Keith and Noelle have two children, Jennifer born in October 1980 and Graham in November 1983.

1981 saw some shifting from field selections and scion collection to orchard management and Keith was promoted to the Supervisor of the Skimikin orchard site. Reasonable crops were produced in 1987 and 1989 and then came the giant crop of 1993.

Over Keith's tenure, since 1978, the Skimikin Seed Orchard has grown to be the second largest Ministry seed orchard with over 20,000 seed producing trees of spruce, white pine, lodgepole pine, yellow pine and paper birch. Keith has left the Skimikin Seed Orchard in great shape to produce the next generation of improved seed for the interior of British Columbia.

Photo 9.2. Keith Lyle.

[illegible]

Carolyn Lobe began her Forest Service career January 2, 1992, at Saratoga Seed Orchard and worked there until her retirement in January 2015.

Coming from an agricultural background in Alberta, Carolyn quickly adapted her Bachelor of Science in Agriculture plant science and horticulture expertise towards forest stock and seed production. Under Carolyn's steady guidance, the Saratoga Seed Orchard transformed from being a single species, single orchard site to hosting five species of almost 5,000 trees including the new 3rd generation coastal Douglas-fir. Due to this site transformation, Carolyn became an expert in drainage systems, irrigation systems, septic systems, heating systems, alarm systems, greenhouse management, fence and road construction, tree reproductive biology, tree nutrition and fertilization, analysis and application, along with a myriad of other details that are required in running a modern day seed orchard site.

When not working at the orchard, Carolyn, husband Wayne, and children Sam and Kristal were heavily involved in the local 4-H Horse Club, as well as breeding, raising and showing Quarter horses.

In 2006, Wayne's employment required the family move to Olds, Alberta. Carolyn remained with the seed orchard and became a Wenger commuter until her retirement when she returned to married life, joining Wayne on the farm in Olds. Her daughters live nearby and Carolyn is enjoying spending time with Wayne and the girls and extended family all living in Alberta. She has taken over many of the farm maintenance projects and spends much of her time training and riding their many quarter horses, being entertained by and caring for their two Great Dogs, Jake and Stella, and generally enjoying living on the farm with views of the Rocky Mountains from the pasture.

Pictured: Carolyn Lobe, when planting at Saratoga Seed Orchard

[illegible]

After 29 years with the Forest Service, Gladys retired on February 7, 2015 from the Saratoga Seed Orchard as a Forest Technician.

Gladys began her career as an excellent Orchard Technician at the Kalamalka Seed Orchard in Osoyoos. During the period of time, the G1000 SSP seed Orchard was being developed and Gladys was a main focal point working between the two sites. Upon privatization of the Kalamalka Seed Orchard in 1999, Gladys was transferred to the G1000 SSP Seed Orchard. When necessary, she also assisted with field duties at the Saratoga Seed Orchard and upon closure of the G1000 SSP Seed Orchard on April 1, 2003, Gladys was transferred to the Saratoga Seed Orchard. Thus, Gladys has worked at most of the summer coastal seed orchard sites over time and has always shown her adaptability and versatility in working at new locations and with new species, quickly and competently getting down her duties. One thing we know Gladys won't miss is the daily commute from G1000 SSP to Saratoga.

We will miss Gladys but are happy to know that she is now enjoying her well earned retirement by spending more time with her husband George, their children and grandchildren. She can now spend more time working in her garden, enjoying her horses and painting with the family local farming business. Gladys has a new puppy, Emma, and she is enjoying the training regime.

Pictured: Gladys Smith at work and enjoying her new puppy Emma, in retirement

[redacted]

Ray Cardy retired on May 1, 2015 after 38 years with the Forest Service.

Ray began his career with the Forest Service on March 3, 1977 as a silviculturist on the Schenkel District on Siuslaw. Duties included all aspects of cutunder and basement operations, seed and cone processing, irrigation, storage and shipping seeds.

In 1979 Ray was promoted to a District Technician where he provided assistance to the Quality Control Technician which included record maintenance, cultural regimes, and tree and growth monitoring. In 1982 he was promoted to Quality Control Technician. In 1988 Ray became and was scheduled as Operations Supervisor. Ray left the Forest Service in 1989 due to the privatization of the Schenkel Nursery. However, after the privatized nursery closed in 1992, Ray returned to the Forest Service as a Forest Technician at the Bonner Seed Orchard.

During Ray's tenure at the Bonner Seed Orchard he especially is/she significant accomplishments such as the establishment of the second generation Douglas-fir orchard (SO2), and the 1993 second Ponderosa pine seed production (SP1993) bgs of cones to seed. Ray is proud of the effort and contribution he and his co-workers made supporting the reforestation work which took. To date, Ray and staff at the Bonner Seed Orchard have produced, during Bonner's 47 year existence, over 1,250 bulk pounds of improved seed – enough for 50 million seedlings.

During a visit with his father at the Columbia Hospital in 2000, Ray met his partner Sue and support Angie. Sue was Ray's father's favorite nurse and Ray always told us that it was a blessing that something good came out of the sad situation. At his go-a-ceremonies, Ray looks forward to pursuing his passion which include fishing, spending time with his dogs and roaming Canada in his motorhome.

Ray at Alpa cafe

[redacted]

Phyllis Taylor retired on March 31, 2015. Phyllis has contributed 20 years to the Forest Service and has been working at the Bonner Seed Orchard as a Forest Technician since September 16, 1995.

Prior to Phyllis' years with the Forest Service, she held several working positions at Plum Creek Companies in Colfax from Georgia. From 1992 to 1995, she was responsible for overseeing logging crews from Plum Creek out on sporting areas, as logging access to the forest properties. Prior to included Bonner Mills 1991. Among Ms. Taylor's years with Crystal Springbrook Nursery in Post Falls to in Washington DC and speaking tours throughout the United States including Hawaii.

In 1974 Phyllis met her husband, Wayne and worked at an Insurance Brokerage in Grand to Superior Paper in Vancouver BC until 1981. In 1981, while living in Vancouver, BC, Phyllis and Wayne daughter twins were born. The following year, Phyllis and Wayne relocated to Deep Bay and started a Business. Today, Wayne is a full time and works out of Deep Bay.

Phyllis worked into the role of Cone was home makes from 1981 to 1991 and became involved with community activities, providing programs including scouts, soccer, Brownies and Girl Guides games. She was also the secretary for the Lighthouse Association Commission.

Phyllis accepted a job on September 16, 1991 and was hired by Gordon Mathews for the position of Forest Technician in the Bonner Seed Orchard. Phyllis assisted on a number of seed orchard activities.

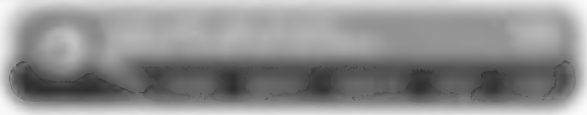
During Phyllis' retirement years, she hopes to make christmas calling to ride on ship and to Phyllis moved to Post Falls and is an interest on Facebook. Wayne has been working for the last 35 years.

Take on Phyllis' future retirement

[redacted]

[redacted]

[redacted]



Appendix 1 FGC Seed Planning Unit

Seed planning unit (SPU)					Program category
#	Species	Common Name	SPZ	Elev. band (m)	
1	Fdc	Douglas-fir	W	1-900	1
2	Cw	Western redcedar	W	1-700	1
3	Hw	Western hemlock	W	1-600	2
4	Sx	Interior spruce	NE	1000-1700	1
5	Sx	Interior spruce	NE	1700-2100	2
6	Se	Sitka spruce	W	1-500	2
7	Pli	Lodgepole pine	NE	700-1600	1
8	Pw	Western white pine	W SW	1-1000	1
9	Be	Amabilis fir	W	1-1000	3
10	Pli	Lodgepole pine	TO	700-1400	1
11	Yc	Yellow cypress	W	1-1100	2
12	Pli	Lodgepole pine	PG	700-1400	1
13	Lw	Western larch	NE	700-1600	1
14	Sx	Interior spruce	PG	600-1400	1
15	Pw	Western white pine	KO	500-1400	1
16	Pli	Lodgepole pine	TO	1400-1600	1
17	Pli	Lodgepole pine	BV	700-1400	1
18	Pli	Lodgepole pine	CP	700-1300	1
19	Fdc	Douglas-fir	SW	200-1000	2
20	Pli	Lodgepole pine	NE	1600-2000	2
21	Fdi	Douglas-fir	NE	400-1200	1
22	Fdi	Douglas-fir	NE	1000-1900	2
23	Se/Sx	Spruce	SM NIST	all	2
24	Hw	Western hemlock	W	600-1100	2
25	Sx	Interior spruce	EK	750-1800	2
26	Pli	Lodgepole pine	PG	1400-2000	3
27	Cw	Western redcedar	SW	200-1000	2
28	Sx	Interior spruce	TO	1300-2100	2
29	Pli	Lodgepole pine	EK	1100-2000	2
30	Sx	Interior spruce	TO	700-1500	1
31	Fdc	Douglas-fir	W	900-1200	2
32	Pli	Lodgepole pine	EK	800-1500	2
33	Cw	Western redcedar	W	700-1500	2
34	Lw	Western larch	EK	900-1700	1
35	Sx	Interior spruce	BV	500-1400	2
36	Bg	Grand fir	W	1-700	3
37	Fdi	Douglas-fir	GL	700-1400	2
38	Hw	Western hemlock	W north	1-400 (part of SPU 3)	
39	Fdi	Douglas-fir	EK	700-1400	2
40	Sx	Interior spruce	FR	<650 & 850-1200	2
41	Fdi	Douglas-fir	PG	700-1200	2
42	Sx	Interior spruce	PG	1200-1550	2
43	Fdi	Douglas-fir	CT	600-1400	2
44	Sx	Interior spruce	NE	1-1000	1
45	Pli	Lodgepole pine	BB CHL	All	3
46	Ep	Sub-alpine fir	all int	all	3
47	Ba	Noble fir	W	all	3
48	Aspen/birch/cottonwood		Interior	-	3
49	Alder/poplar/maple		Coast	-	3
50	Lw	Western larch	NE	1200-1800	2
51	Py	Ponderosa pine	S. Interior	500-1200	2

Appendix 2 Tree Species

CONIFERS	LATIN NAME	TREE SPECIES CODES
western redcedar	*Thuja plicata*	Cw
yellow cypress	*Callitropsis nootkatensis*	Yc
Douglas-fir	*Pseudotsuga menziesii*	Fdc
interior Douglas-fir	*Pseudotsuga menziesii* var. *glauca*	Fdi
amabilis fir	*Abies amabilis*	Ba
grand fir	*Abies grandis*	Bg
noble fir	*Abies procera*	Bp
subalpine fir	*Abies lasiocarpa*	Bl
mountain hemlock	*Tsuga mertensiana*	Hm
western hemlock	*Tsuga heterophylla*	Hw
Rocky Mountain juniper	*Juniperus scopulorum*	Jr
alpine (subalpine) larch	*Larix lyallii*	La
western larch	*Larix occidentalis*	Lw
limber pine	*Pinus flexilis*	Pf
lodgepole pine	*Pinus contorta*	Pl
interior lodgepole pine	*Pinus contorta* var. *latifolia*	Pli
ponderosa pine	*Pinus ponderosa*	Py
shore pine	*Pinus contorta* var. *contorta*	Plc
western white pine	*Pinus monticola*	Pw
whitebark pine	*Pinus albicaulis*	Pa
Englemann spruce	*Picea engelmannii*	Se
Sitka spruce	*Picea sitchensis*	Ss
white spruce	*Picea glauca*	Sw
spruce hybrid (interior spruce)	*Picea* cross (Se and Sw mixtures)	Sx
Sitka x unknown hybrid	*Picea sitchensis* x	Sxs
western (Pacific) yew	*Taxus brevifolia*	Tw

HARDWOODS		
red alder	*Alnus rubra*	Dr
black cottonwood	*Populus balsamifera* ssp. *trichocarpa*	Act
hybrid poplars	*Populus* spp.	Ax
trembling aspen	*Populus tremuloides*	At
paper birch	*Betula papyrifera*	Ep
Garry oak	*Quercus garryana*	Qg

Appendix 3 Author Contact List

CONTRIBUTOR	AFFILIATION	TELEPHONE NUMBER
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Woods, Jack	SelectSeed	604-734-5778
Xie, Chang-Yi	MFLNRO	250-387-8911

Cone Processing

Cone storage, conditioning and extraction to separate seeds from cones

Seed Processing

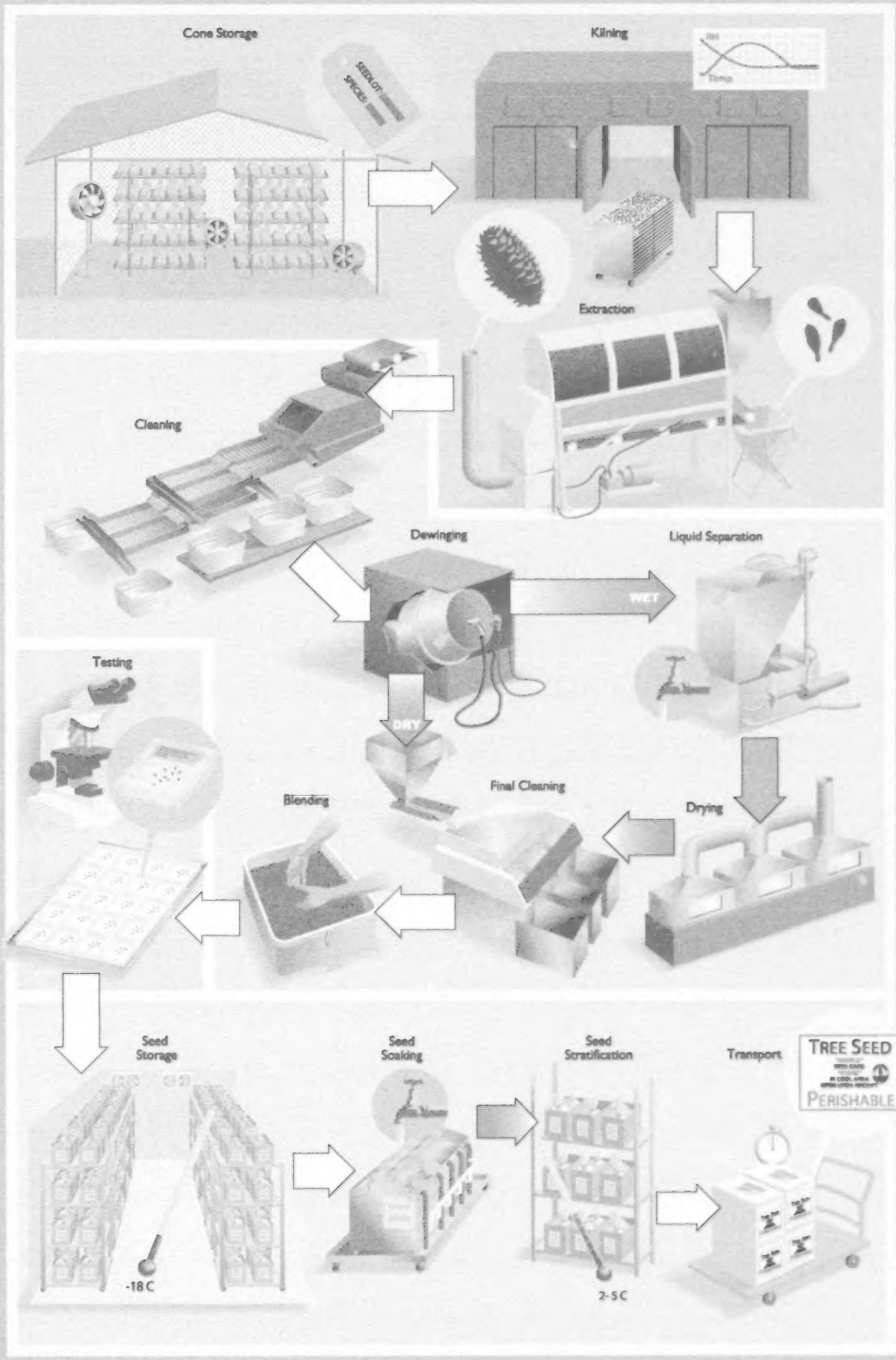
Removal of debris, dewinging, drying, removal of non-viable seeds and blending

Testing

Quantify cone and seed quality for decision-making, storage and use

Inventory Management

Seedlot registration, storage, pretreatment and distribution of seed



BRITISH COLUMBIA

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FOREST SERVICE BRITISH COLUMBIA

FGC Forest Genetics Council of British Columbia